

# NATIONAL ENGINEERING ROBOTICS CONTEST 2018



## THEME: INDIGENOUS CATEGORY

National Engineering Robotics Contest

A joint venture of NUST and STEM Careers Programme (HEC)

Organized by:

Department of Mechatronics Engineering,

College of Electrical and Mechanical Engineering,

National University of Sciences and Technology, Pakistan

## 1 CHANGE LOG

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The table below will list the pages on which changes have been made to the theme.

Revision Date	
12/09/2017	Page no.6 Figure 1.
	Page no. 7
	Page no. 9
09/02/2018	Page no.6 Figure 1.
	Page no.8

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### 3 INTRODUCTION

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The National Engineering Robotics Contest is a joint project of the National University of Sciences and Technology and STEM Careers Programme HEC to promote research in robotics and its related fields in Pakistan. We, from the Department of Mechatronics Engineering welcome you all to participate in 16<sup>th</sup> National Engineering Robotics Contest (NERC 2018). This competition will provide a common platform for the integration and evaluation of various electromechanical designs, control and path planning algorithms, and agent architectures. Over the years, NERC has grown increasingly popular among students as well as engineering departments across the country. Engineering students from all over Pakistan participate in this competition. This not only adds value to the competition but also resolves our pledge to bring exciting new challenges every year for the advancement of robotics community at an increasingly wider scale. Robotics is a buzz word at today's technology forefronts. Due to exponential advancements in fields like high performance computing, computer vision, computer networks, material sciences and power electronics, the growth experienced by robotics in past few years is unprecedented. Robotics is the only field which can add precision while replacing the slow manual labor in the contemporary industrial world. Thus, this field faces enormous pressure from industry to produce all-purpose mobile manipulator robots which can perform simple tasks like grab, navigate and place objects at desired locations autonomously. The future of Pakistan relies heavily on advancement in the fields of engineering and science and events of this nature will encourage and motivate students to improve their technical skills in leaps and bounds.

Given the high demand of robots in disaster management operations, this year's theme has been designed to bring together major aspects of robotic disaster management to the forefront. We hope this theme will not only raise awareness about the use of robots in disaster management but also propel major universities to come up with innovative solutions to help when calamities such as natural disasters strike our country.

## 4 CATEGORIES

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There are two categories of the contest: Indigenous Robot category, and Modular Robot Category. The purpose of this contest is to develop a sense of problem-solving, technical design and ingenuity among the contestants.

### 4.1 INDIGENOUS

Indigenous category includes robots that are constructed from scratch. Their mechanical structure, controls etc. are designed and fabricated by the teams themselves. The electronic control modules (including all electronic boards and motor drivers etc.) should be designed and manufactured by the students.

### 4.2 MODULAR

Modular/Lego category includes robots that are developed using ready-made kits for example Lego, EV3 kits.

*This document describes the theme for Category 1 – Indigenous Robots.*

## 5 CONTEST STRUCTURE

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The contest will consist of two stages:

1. Heats/Qualifying Rounds
2. Head to head matches.

### 5.1 QUALIFYING ROUNDS

Each robot will participate in the qualifying rounds (heats). There will be no head to head matches in heats. For qualifying rounds following rules will be observed:

- 5.1.1 There will be NO head to head matches. Each team will individually run their robots.
- 5.1.2 If the points of both teams are equal, decision will be made based on time taken by both team. The team with shortest time will be declared winner. If time of both teams is also same the decision of the winner will be based on the shortest distance from the next objective from the current position.
- 5.1.3 Each team will be provided maximum of 3 minutes to run their robots.

- 5.1.4 A team can take as many retries as it want within 3 minutes without any penalty but only the total time taken by the team will be recorded.
- 5.1.5 When the team takes a retry the score is reset to zero.
- 5.1.6 When the team is ready and the whistle is blown, time will be started.
- 5.1.7 If a robot is not able to successfully complete the task in time then the time when team will call it off will be recorded as the finish time.

## 5.2 HEAD TO HEAD MATCHES

The top 32 teams from the qualifying rounds will go on into the final rounds for head to head matches. The winners will be decided through a final match. Runners up will be decided based on the outcomes of the semi finals and quarter finals.

# 6 CONTEST THEME

The theme of NERC 2018 is “Geological Exploration”. The robot will move around valleys and canyons to explore the area for its geology, climate and water availability by placing different types of “sensors” at various designated “sites”. Unfortunately, the robot has no knowledge of its own location in the territory. It has to localize itself in order to reach different “sites”. The “sites” are represented by colored boxes and the “sensors” are represented by white table tennis balls. The first team to place all the “sensors” at the correct “sites” will be declared the winner.

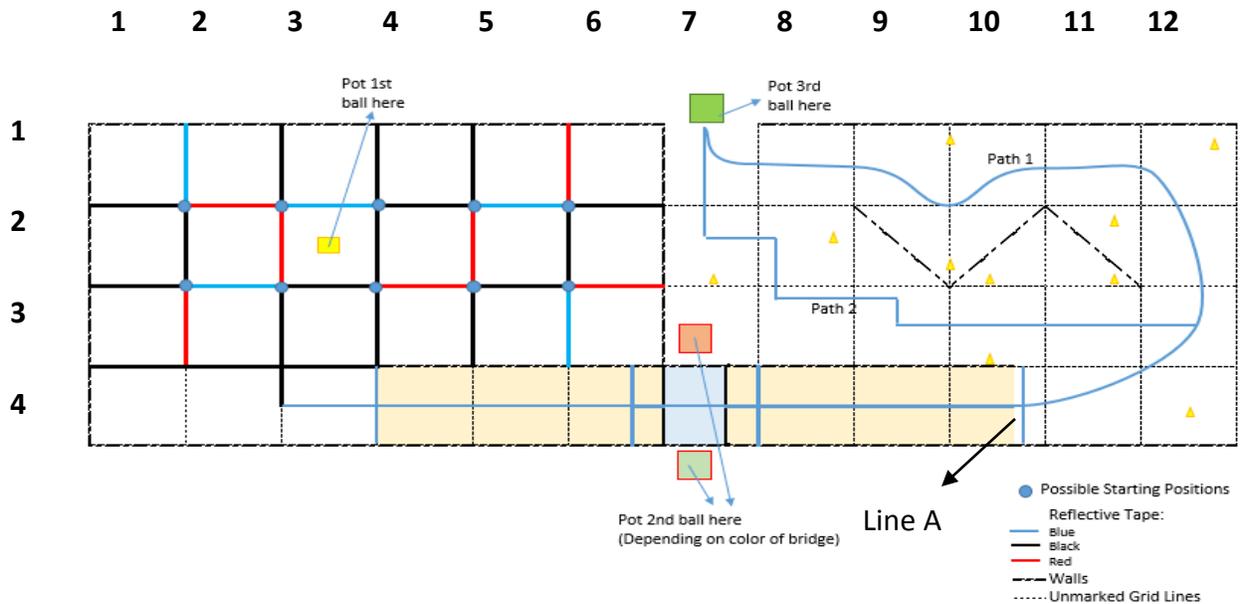


Figure 1 Contest Arena (Top View)

- 6.1 The Contest arena shown in *Figure 1 Contest Arena* consists of two sub arenas, both the sides are identical to each other and their colored boxes locations are similar.
- 6.2 Laminated wooden sheets (lasani) are used for the construction of the arena. The floor of each will be of the white colour shown in the map.
- 6.3 The walls have a height of 4 inches throughout the arena.
- 6.4 Each Sub arena is divided in to two zones Z1 and Z2.
- 6.5 Zones Z1 and Z2 are connected via a bridge.
- 6.6 Each sub arena has 4 sites. Z1 has one site. Z2 has 3 sites. The location and color of the sites are fixed.
- 6.7 The size of the site in Z1 is 4x4x6 inches while the size of the sites in Z2 is 6x6x6 inches.
- 6.8 The robot will start its operation from Z1.
- 6.9 The robot can only enter in zone Z2 from Z1 by crossing the bridge. The bridge is as shown in Figure 1. Contest Arena. The robot must cross the bridge.
- 6.10 The starting position of the robot in Z1 will be random. The robot will be placed on any one of the 10 cross section points marked with blue circles in *Figure 1 Contest Arena*. The orientation of the robot will also be random.
- 6.11 The robot will follow the colored lines in order to localize itself and find the site placed in Z1.
- 6.12 After Stopping at the site (placed in grid location 2,3) in Z1, the robot can pot the sensor in the site from any direction. The color of the site (box) is yellow.
- 6.13 The robot may not throw the table tennis ball. It can only drop the ball after Stopping at the grid located at (2,3) for the yellow box as shown in Figure 1. Contest Arena in Z1. The robot or an extension of the robot must be present in the grid unit present at the location (2,3) as shown in Figure 1. Contest Arena in order to pot the sensor in the box.
- 6.14 The robot must reach inside the grid unit (2,3) and drop the ball (irrespective of correctly potted or not), only then will the robot be allowed to climb the bridge.
- 6.15 For Z2, the sensors must be dropped in the site while standing on the bridge.
- 6.16 There will be a site placed on both sides of the bridge. The site on the left side of the bridge is red and the site on right hand side of the bridge is blue.
- 6.17 The robot will sense the colour while standing at the top of the bridge and then must drop the sensor in the correct colored box. The color of the bridge top will be either red or blue.
- 6.18 The task of the robot will be completed successfully after potting the ball in the 3<sup>rd</sup> (green) box. The robot must stop at the grid location (1,7) in order to pot the sensor in the box.

- 6.19 The robot should choose between Path 1 or Path 2 in order to reach the green box. Traffic cone hurdle pairs will be placed along the line at a perpendicular distance of 8 inches from each side of the line.
- 6.20 The pair of cone hurdles will be placed at three random locations along the path. In order to avoid collision with the cone hurdle, the robot may follow the line.
- 6.21 If a robot displaces any cone hurdle, a penalty will be given (see section 9.1 for penalty details). For example, if a robot hits the left hurdle of the hurdle pair, it will earn one penalty. If the robot again hits the right hurdle of the same hurdle pair, it will earn another penalty.
- 6.22 The sensors are considered to be white table tennis balls. Standard table tennis balls will be used with a diameter of 40mm.
- 6.23 The robot should have the balls preloaded.
- 6.24 The angle of the two ramps of the bridge ranges between 9-13 degrees.
- 6.25 The sites are the coloured boxes.
- 6.26 Though the locations and colour of the sites in Z2 are fixed, the colour of the top of the bridge is not fixed. It can either be red or blue.
- 6.27 The arena is divided into grid units represented by the dashed lines. Each grid unit is 18" x 18". These lines will not be visible.

## 7 ROBOT OPERATION

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The qualifying teams (those which qualify for the final rounds) will compete with each other in a knockout format. In each match two teams will be pitted against each other, running their robots side by side in the contest arena. Teams will be declared as Team A or Team B based on the coin toss before every match. Team A will run their robot in the left side and Team B will run their robot right side.

Once turned on, the robot must be self-controlled without any human intervention. Remote-control of any sort (wired or wireless) CANNOT be used. Contestants are NOT allowed to touch their robots or enter the Contest Arena after startup. After the blow of whistle, the robot will have 3 minutes to complete the task.

During a retry the layout of the arena shall remain SAME however the point scoring will restart from zero. Any of the preloaded objects of the robot that are in the arena will be loaded in the robot again. The robot may navigate through the arena using any suitable technique. The robot may not displace any box. Displacing any item inside the arena will result in a retry. If the participating team sees that their robot has lost track of its location and is facing trouble localizing itself, the team can ask for a retry. During its motion, the robot may touch the walls of the arena without damaging them but it is not allowed to use any sort of tactile sensor to sense the walls or obstacles. This will result in disqualification.

In case of a tie, the contestant may be required to run a rematch on the discretion of the judges.

For a particular match, both teams will face the same layout of the arena. Winning will depend on smart decisions and swift execution of the task.

## 8 POTTING TECHNIQUE

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- 8.1 The robot may not throw the table tennis ball. It can only drop the ball after Stopping at the grid located at (2,3) for the yellow box and the grid location (1,7) for the green box as shown in Figure 1. Contest Arena in Z1 and Z2 respectively. The robot or an extension of the robot must be present in the grid unit present at the location (2,3) as shown in Figure 1. Contest Arena in order to pot the sensor in the box.
- 8.2 In case of Z2, the robot must drop the ball in the site(box) while standing at the top of the bridge.
- 8.3 In order to pot the ball in case of 8.1 and 8.2, the robot may use an extension(s). However, the robot can only extend its parts during the ball potting operation.
- 8.4 The robot must close its extension(s) after potting the ball.
- 8.5 If the robot fails to close its extensions in case of either 8.1 or 8.2 this will result in a forced retry.
- 8.6 The maximum size of robot extension(s) is 12 inches.

## 9 POINTS

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The point scoring is shown below in Table 1 Point Scoring.

*Table 1 Point Scoring*

	<b>Task</b>	<b>Points</b>
<b>1</b>	*Stopping at the grid unit (2,3)	10 Points
<b>2</b>	Putting sensor at site 1	20 Points
<b>3</b>	Reaching the bridge top	10 Points
<b>4</b>	**Putting sensor at site 2	20 Points
<b>5</b>	Crossing Line A	10 Points
<b>6</b>	*Reaching at the grid unit (1,7)	10 Points
<b>7</b>	Putting sensor at site 3	20 Points
	Total Points	100 Points

\*Reaching means that any two tires of the robot must be present inside the specified grid unit.

\*\*Putting the sensor at the wrong site will result in only half points.

## 9.1 DEDUCTION OF POINTS

The deduction of points is show below in Table 2 Deduction of Points

*Table 2 Deduction of Points*

		<b>Deduction/Penalty</b>
<b>1</b>	The robot displaces a cone	5 points
<b>2</b>	The robot fits in an area of 12 in X 12 in square	No Penalty
<b>3</b>	Oversize Robot (14 in X 14 in square)	5 Points
<b>4</b>	Oversize Robot (exceeding 14 in X 14 in square)	Disqualification
<b>5</b>	Robot height exceeding limit (12 in)	Disqualification
<b>6</b>	Robot weighs less than 12 kg	No Penalty
<b>7</b>	Overweight Robot (Weight between 12 and 14 kg)	5 Points
<b>8</b>	Overweight Robot (Weight exceeding 14 kg)	Disqualification
<b>9</b>	Damaging the arena/wall/sites/ramp	Disqualification

## 10 RULES

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The following are the rules governing the contest.

### 10.1 GENERAL

- 10.1.1 The Contest judges may stop any robot at any time if they feel that it is performing, or is about to perform, any action that is dangerous or hazardous to people or equipment.
- 10.1.2 All Electronic Circuitry must be designed and fabricated by the Contestants themselves.
- 10.1.3 Maximum effort in the design and fabrication of the robot should be generated by contestants themselves.
- 10.1.4 Contestants are allowed to use only certain electronic components, list for which is attached at the end.
- 10.1.5 Additional information regarding the contest rules and regulations may be found in the FAQs and will be considered as part of the theme and rules. New FAQs are uploaded frequently so keep watching the FAQ corner for new information.
- 10.1.6 Any correspondence with the NERC officials via e-mail telephone or any other means will not be considered as part of the rules.
- 10.1.7 You cannot pick or place any object over the walls.

- 10.1.8 If both the teams have scored same points but are not able to complete the task in allocated time slot decision of the winner will be on judges' discretion who will determine which robot is closer to finish the task first.
- 10.1.9 If both teams have scored the same points, have the same time and are at the same distance from the finish point, a coin toss will be used to decide the winner.
- 10.1.10 If any team wants to launch a protest (of any kind), they must do so within 15 minutes of the end of their match. The procedure is outlined in an x B. The following behavior shall be considered for disqualification by the referee and the team could possibly be disqualified:
- 10.1.10.1 Attempting to damage the game field
- 10.1.10.2 Performing an act that fails to comply with the spirit of Fair Play.
- 10.1.11 In all matters of interpreting the rules before and during the Contest and in any issues not covered by these rules, the decisions of the Contest Judging Committee will be final.

## 10.2 TEAMS

- 10.2.1 The Robots can be built by teams of currently registered students from Engineering Institutions and Polytechnic Institutions. Each team can comprise of a **maximum 6 members**.
- 10.2.2 If the students from two different Institutes/Universities join hands and form a team in collaboration then the name of the Institute/University with maximum number of students in such a team would be registered.

## 10.3 ROBOT SIZE AND WEIGHT

The robot must fit within 12 in X 12 in square at the time of the measurement. If the area of the robot base is more than a 12 by 12 in square, but less than a 14 by 14 in square, then points will be deducted. The size of robot extension will be measured at the time of measurement. The maximum possible size of robot extension is 12 inches. The maximum permissible height of the robot is 12 in. Any robot which does not fit in 14 in X 14 in square or exceeds a height of 12 in will be disqualified. All robots will be carefully measured. All sensors mounted on the robot will be counted as part of the robot's total dimensions. If contestants want to add a flag, hat or other purely decorative, non-functional items to the robot, they may do so. The decorations may be removed for measurement purposes. The weight of the robot excluding decorations must not exceed 12 kg. Penalties as detailed in 9.1 Deduction of Points will be levied if the robot does not fulfill the size and/or weight criteria.

## 10.4 ROBOT OPERATION

- 10.4.1 Any team that damages the arena will be disqualified.
- 10.4.2 The robot must not use any harmful substances such as oil, petrol etc. in its operation that can damage the arena.
- 10.4.3 The Robot CANNOT split after the start of the game, only one Robot is allowed to compete at a time.
- 10.4.4 The robot must not use any destructive or dangerous methods to displace any obstacle or box.

## 10.5 SENSORS

- 10.5.1 Robot is not allowed to use tactile sensor of any type for sensing the walls.
- 10.5.2 Ultra-Sonic Range detectors (SONARs) or IR based proximity sensors (models specified in the components' list attached) must be used for sensing walls.
- 10.5.3 The team may use any off-the-shelf encoders if they feel the necessity. Self-made encoders from discrete components are also allowed.

## 10.6 ELECTRONICS

- 10.6.1 All electronic circuitry must be designed and fabricated completely by the participants themselves. Circuits should not be fabricated by the help of any professional developers. Only the modules specified in the components list may be bought directly.
- 10.6.2 the participants must not use any pre-fabricated board or electronic circuitry. Any type of the electronic board or circuit must be etched by the students themselves. Circuits should not be fabricated by the help of any professional developers.
- 10.6.3 Any type of the electronic board or circuit must be etched by the students themselves. Circuits should not be fabricated by the help of any professional developers
- 10.6.4 Microcontrollers specified in the component list must be used for controlling your robots. You can also use Microcontroller development boards specified in the list only. Microprocessors and Single Board Computers are not allowed.
- 10.6.5 Motor drive circuits should be designed and fabricated by participants themselves and made from discrete components like Transistors and logic circuitry. H-bridge IC's like L297 or L298 are not allowed. However you may use Gate driver IC's e.g. IR2101/IR2110 etc. These restrictions apply only to the drive circuits and not those used to control the mechanism.

- 10.6.6 No prefabricated modules are allowed, unless listed in the components list or allowed by the NERC coordinator. If a component needs to be added then all of its specification (datasheet, picture, location to purchase, price) MUST be emailed for formal permission.
- 10.6.7 All other components can be used in your circuitry. In case of any query, questions shall be emailed to NERC Coordinator at [nerc@ceme.nust.edu.pk](mailto:nerc@ceme.nust.edu.pk) . The FAQs section on the website shall be considered part of the theme.

**Note: Only the theme documents and the questions in the FAQ section of the official website ([www.nerc.com.pk](http://www.nerc.com.pk)) shall be considered as official notifications.**

## 10.7 POWER SUPPLY

- 10.7.1 The robot must be battery-powered.
- 10.7.2 The robot must not have any wired connections with its surroundings.
- 10.7.3 Voltage of the machine's electrical power source must not exceed 48 volt DC. **Power banks may be used.**
- 10.7.4 Power sources that are considered dangerous or unsuitable by the contest Officials shall not be permitted.

## 10.8 DURATION OF MATCH

- 10.8.1 Each match will be of maximum 3 minutes.
- 10.8.2 Teams will be given 1 minute for setting up the Robot at the start.
- 10.8.3 Robot can start at the instant when the start signal is given and a whistle is blown. Robot must be constructed so that it can be started in minimum possible steps.
- 10.8.4 Once the Robot moves, team members will not be allowed to touch the Robot or enter the Contest Arena.
- 10.8.5 Timing shall start once the start signal is given and the whistle is blown.
- 10.8.6 Time would be stopped as soon as robot drops the sensor in green box in Z2. If a robot is not able to successfully complete the task then the time when team will call it off will be recorded as the finish time. The team must leave their robot as it is on its current location when time stop is called by them. They may NOT pick their robot up till the

referee announces the end of the match. The team is not allowed to take a retry after the time has stopped.

10.8.7 The team which drops all 3 sensors in the correct sites will be declared the winner of the match.

10.8.8 If both teams fail to drop all 3 sensors, within the time limit, the team scoring more points will be declared the winner of the match.

10.8.9 If both the teams have scored same points but are not able to complete the task in allocated time slot decision of the winner will be on judges' discretion who will determine which robot is closer to finish the task first. The distance of the robot's current location from the Finish Point will be measured in terms of grid units.

## 10.9 RETRY

If the robot is strayed due to some reason, retries are allowed.

10.9.1 There is no limitation on the number of retries and a team can take as many retries within the 3 minutes duration of the match. No Points will be deducted for retries.

10.9.2 Each team would be provided a flag of their respective team. If a team wants to take a retry, the flag bearer must raise the flag and say clearly "retry". Once the referee announces a retry, the team shall place its robot at its starting location and will reload all the sensors(balls) in the robot.

10.9.3 If a team wants to stop their robot during the match, the flag bearer must raise the flag and say "stop". The team can then turn off their robot but they must not move it. The time at which the robot is stopped would be recorded as the final time.

10.9.4 For each retry, robots must be started again from the Start point. Points will reset to zero.

10.9.5 Separate time for individual retries will NOT be recorded or maintained. When a team takes a retry it is only allowed to restart the robot.

10.9.6 Changing the microcontroller or reprogramming the robot is **Not Allowed**. A team may change the batteries of the robot if required.

10.9.7 If the contestants enter the arena during the match, it will automatically be counted as a retry.

10.9.8 Referring to Para 8 of the theme, if the robot fails to close its extensions in case of either 8.1 or 8.2 this will result in a forced retry.

## 10.10 DISQUALIFICATION

The following behavior shall be considered for disqualification by the referee and the team could possibly be disqualified:

10.10.1 Attempting to damage the game field.

10.10.2 Performing any act that fails to comply with the spirit of Fair Play

## 10.11 PROTEST PROCEDURE

The protest procedure is as follows:

10.11.1 The team must launch a protest (submit a complete protest form to the head jury) within 15 minutes of the end of their match.

10.11.2 The team must collect the protest form from the head jury on request or use a hard copy of the form in Anx D.

10.11.3 The team must submit a protest fee of Rs. 5000/- along with the protest form.

10.11.4 A complete protest form includes submission of the protest fee.

10.11.5 The head jury will forward the case to the judges.

10.11.6 The judges will decide on the protest's validity and render their decision.

10.11.7 The judges' decision will be final.

10.11.8 In case of noncompliance of any of points above the protest will not be considered valid.

## 11 TEST RUN

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Contestants will be given time for trial run one day before the contest to calibrate their robot/sensors on the actual arena/game field.

## Annex A COMPONENTS LIST

Please see the components below. In case of any query, questions shall be emailed to NERC Coordinator at [nerc@ceme.nust.edu.pk](mailto:nerc@ceme.nust.edu.pk). The FAQs section on the website shall be considered part of the theme.

Table 3 Components List

<b>Sensors</b>	<b>Allowed Parts</b>
<b>Wall Sensor (Proximity Sensors)</b>	1) IR Sensors: Sharp GP2Dxx & GP2Y0xx series sensor 2) Sonars: MaxbotixMaxsonar Range Finder series (XL,LV Parallax PING)) Ultrasonic sensor, HC-SR04 3) Self-made from discrete components
<b>Colour Sensor</b>	1) ADJD-S371-QR99 RGB sensor 2) Self-made from discrete components 3) TCS230 or TCS3200
<b>Other Sensors</b>	1) Compass/Magnetometer: HMC5883L 2) IMU: MinIMU-9 v3 Gyro Accelerometer and Compass (L3GD20H and LSM303D), MPU-6050 Accelerometer + Gyro 3) IMU: GY-80 ADXL345 Accelerometer 4) Accelerometer : ADXL345 5) Gyro: LPR550AL Dual-Axis (Pitch and Roll or XY) Gyro ,LPR550AR Dual-Axis (Pitch and Roll or XY) Gyro
<b>Microcontroller</b>	1) PIC16F/PIC18F family 2) AVR ATTiny, ATmega, 3) 8051, 8052, 8055
<b>Development Boards</b>	1) Arduino Mega, Uno, Nano, mini, Pro Series, Leonardo, Esplora, Due 2) Pinguino 26j50 3) Amicus 18
<b>External Shields</b>	Only SD card shield allowed
<b>Motor driver</b>	Self-made from discrete components
<b>Motor</b>	Maximum 2 motors are allowed for the drive purpose There is no limitation of number of motors in mechanism. Encoders may be attached externally.
<b>Battery</b>	Any type (Power Banks are allowed)
<b>Wheels</b>	Meccanum/Omni wheels are not allowed

**Annex B PROTEST FORM**

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**Protest Form**

Team Name:	
Team ID:	
Team University:	
Team Members:	
Match finish time (to be filled by Head Jury)	
Launch time of Protest (to be filled by the head jury)	
Protest fee Payment (to be filled by head jury)	

**Reason of Protest:** \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_  
Signature of Team Leader  
Jury

\_\_\_\_\_  
Signature of Head  
Jury

**Decision of Judges:** \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_  
Signature of Head Judge