POLE BALANCING ROBOT

1. INTRODUCTION:

The competition is among the robots, which support an inverted pendulum that is free to swing around a point with two degrees of freedom, and balance it to keep it vertical by moving the point of support along a horizontal plane.

2. ACCEPTABLE VERSIONS:

2.1 The inverted pendulum may be supported by a vehicle moving along a horizontal plane in order to keep the pole vertical. Any other innovative design, which does not violate the spirit of the competition, may be allowed at the discretion of the judges.

2.2 There is no size restriction on the robot. The overall size will be such that it would be able to operate on the table provided by the organisers. No part of the robot, other than its driving wheels, steering wheels, or encoder wheels, must touch the surface of balance table. It must not fall off the competition table surface during the operation.

2.3 Balancing the pendulum/pole using any form of gyroscopic principle, counter weight, or non-linear friction is not admissible.

2.4 The pole support mechanism and measurement devices should in no way restrict or hold the pole at any time.

2.5 The vehicle must be completely autonomous, with no wires connected externally and with no RF signals or power lines coming from outside.

2.6 There should be no relative motion between the pole-support system and the body of the vehicle.

Fig.1. Pole Dimensions

3. POLE-SUPPORT MECHANISM AND OVERALL SIZE:

3.1. The pole is shown in Fig. 1. The pole should have the dimension shown in Fig.1, with the length of 990 mm and outer diameter of 12.7 mm with a tolerance of 5%. The pole must have uniform cross section and weigh 117 grams with in a tolerance of 5 %. When the pole is placed with its centre on the middle of a support surface of 1.5 cm width, with both sides overhanging, the pole should not topple. A few such poles will be collected from participants and the competition pole will be picked arbitrarily from the lot by the judge.

3.2 The pole will be supplied by the main committee.

3.3 Due to the complex nature of pole angle measurement, the participants are allowed to use their own pole support and measurement subsystems, at this point in time.
4. **Friction Test:**

In order to uphold the integrity of the game, the pole support should offer minimum friction to the swinging pole in all directions.

4.1. Test: The friction of the suspension mechanism is quantified as follows: The pole used for balancing is also used for this purpose. The robot will be placed upside-down to make the pole a regular pendulum.

![Diagram of friction test procedure]

For the test, the robot is supported upside down such that the pole support axle is along the vertical line A, marked on the wall or the platform built for this purpose. There will be two vertical lines on the right side. One (extreme right line B) corresponds to 45° inclination of the pole. The second inner line C corresponds to 18° inclination of the pole, at a distance of 30 cm from line A.

The pole will be moved to side A to reach an inclination of 45° such that the tip touches the outer vertical line B and is released, so that it swings back and forth. At the end of the fifth swing cycle the pole should swing back to side A and reach a minimum angle of 18° such that the tip touches the inner vertical line C.

4.2 The test in section 4.1 will be repeated after turning the robot 90 degrees around the vertical axis and placing it on the same support.

4.3 The judges may also perform the same test at any intermediate angles to satisfy themselves that the pole has two degrees of freedom. In short, the pole should be able to move along a cone surface with the pole support as the vertex, while suffering minimum friction.

4.4. The organizers strongly recommend that the robots have projected supports perpendicular to the base plate at the front and back of the robot, to facilitate easy placement during friction test. See Fig. 3a. The dimensions of the support provided on the robot must be such that the inverted robot can be placed on the friction test structure shown in Fig.3.
4.5. In order to further reinforce the integrity of the game, handlers of each winning robot might be asked to open up the pole support mechanism and pole angle measurement system for inspection by the judges, explain the use of each part in those systems, and answer any query that may arise.

5. COMPETITION PLATFORM:

5.1 The competition table is shown in Fig.4. One common competition table will be used by all competitors. The table will be horizontal with a dimension of 3 m x 1.15 m. There are three regions as shown in Fig.4. A rubber mat of 1.5 mm thickness will be used on the top of the table to improve the grip of the wheels.

6. COMPETITION:

6.1 The robotic vehicle would operate on the top of the platform provided. Please see Fig. 4.

6.2 The vehicle will be placed within the region A. The operator may move the pole (the inverted pendulum) to an upright position and release it upon receiving the signal from the judges. The vehicle must balance the pole in the upright position for a minimum of 20 seconds without the vertical pole crossing the line X-X'.

6.3 Upon completion of the task (in 6.2 above), the vehicle should move across the line X-X' once, and move through the region B, until the pole clears the line Y-Y', without losing balance during transit, i.e. not hitting any part of the table or its own chassis.
6.4 Upon completion of task (in 6.3 above), the vehicle must retrace the path, cross the line X-X’ again and get back to region A. This will complete one cycle. This time, during the retrace, the vehicle need not stay any length of time at region B or A, before the start of the second cycle.

6.5 When an electronic sensing system is used for detecting the pole crossing Y-Y’ and X-X’ lines, the pole sensors at both sides will be placed such that the line of sight of the sensors will be 40 cm above the lines marked on the platform. This may warrant that the robot moves further for the pole to intercept the line of sight of the sensors. This is important since many robots have their poles inclined inwards towards the centre of platform at these points of turning back. Furthermore, no part of the robot other than the pole should be above 25 cm so that no other part of the robot (except the pole) would trigger the sensor.

6.6 The vehicle should repeat these cycles.

6.7 To count these cycles as successful cycles they must be followed by at least 20 seconds of static balancing at region A.

6.8 The robot may continue on (untouched) for more cycles, and complete them with 20 seconds of static balancing at the end, which if successful will be counted cumulatively.

6.9 If a robot is touched by the handler during the trial, it must be restarted for the next attempt.

7. TIME ALLOWED FOR EACH ROBOT

7.1 From the instant the team is called upon to take the arena, 2 minutes will be allowed for set up.

7.2 After the set up time, 5 minutes of performance time will be allowed for each robot. The performance time will start when the participant first releases the robot-pole. However if the set up time exceeds 2 minutes, then performance time will start automatically.

7.3 With in the time permitted, any number of attempts will be allowed. All the attempts must be completed within 5 minutes.

7.4 The participants must vacate the competition area when the 5 minutes of performance time expires.
8. SCORING:
Final score = A x B x C
where
A = 0 if the robot fails initial static balancing
A = 1 if the robot completes initial static balancing
B = number of cycles achieved during run time
C = 1.5, if the robot successfully completes 20 seconds of "the final static balancing" within the performance time.
C = 1.0, if the robot starts "the final static balancing" within the performance time, but the 20 seconds of "the final static balancing" extends beyond the performance time.
C = 0.3, if the robot pole falls before the 20 seconds of "the final static balancing" is completed.

9. CLONING:
9.1 In accordance with the spirit of the competition, clones among the winning entries will only be awarded one prize. Clones will be identified during the "caging" procedure.
9.2 Clones are robots with substantially identical physical appearance and working principles.
9.3 When in doubt, the decision of the Judges will be final.

10. RUBBER MAT USED:
10.1 Brand / Manufacturer & type: Trelleborg SBR 1.5mm - 1.5m:
10.2 Vendor
Khong Lieng Trading Co (Pte) Ltd,
No. 16 KIAN TECK DRIVE,
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