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.

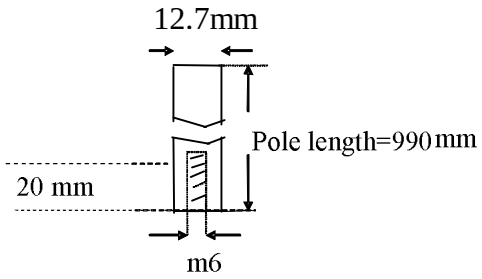

Fig.1. Pole Dimensions

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 **150** 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.

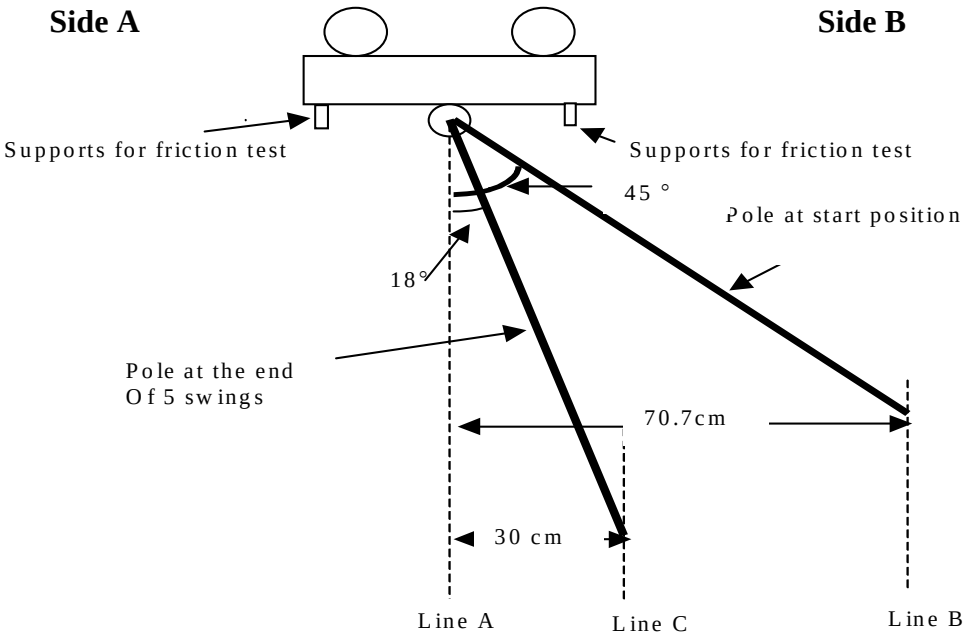

Fig.2 Friction Test Procedure with inverted Robot

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 90degrees 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.

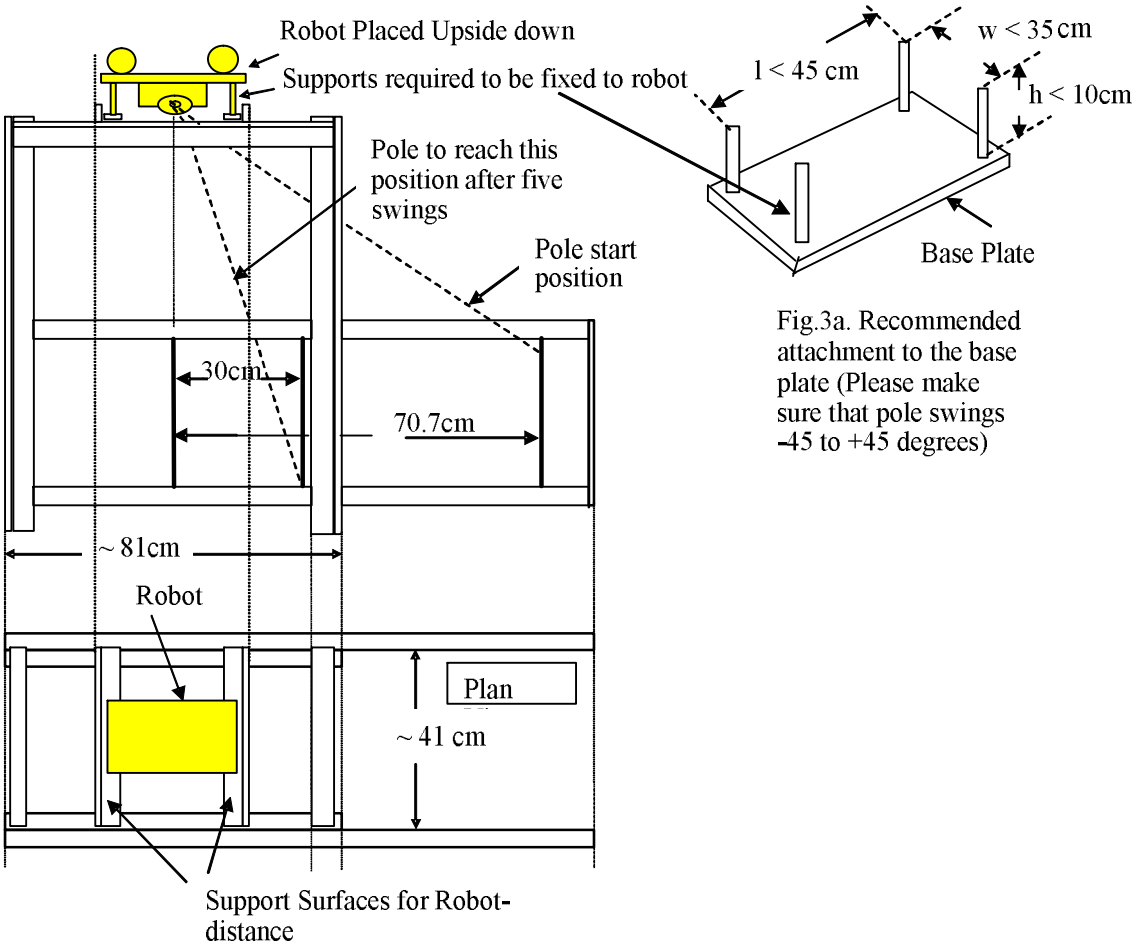

Fig.3a. Recommended attachment to the base plate (Please make sure that pole swings –45 to +45 degrees)

Fig.3. Friction Test Structure

5. COMPETITION PLATFORM:

5.1 The competition table is shown in Fig.4. One common competition table will be used by all competitors. The competition platform consists of a horizontal wooden surface with a dimension of 3 m x 1.5 m. A rubber mat of 1.3 mm thickness will be used on the top of the table to improve the grip of the wheels. Referring to the Fig.4, all double lines shown are retro-reflective tapes. S1 and S2 are separators of dimensions 10cm wide, 1cm thick, and 15 cm tall firmly fitted to the competition table. There are five regions of the competition platform namely A1, A2, B1, B2, and C as shown in Fig.4. Regions A1 and A2 symmetrically divide the platform to the left of the line X1-X2 into two equal parts. Similarly regions B1 and B2 divide the platform equally between lines X1-X2 and Y1-Y2. Region C is the part of the platform to the right of line Y1-Y2. Region C is the crossover area, in which the robot is allowed to go from one side to the other. The two guide-tapes extend into region C for 25 cm. Then, tape forms a semicircle linking the two sides. The centre of the semicircle is on the unmarked middle line of the platform and 25 cm away from the Y1-Y2 line. All dimensions ending on tapes are measured from the centre-lines of the tapes. All dimensions will be within a tolerance of 2%.

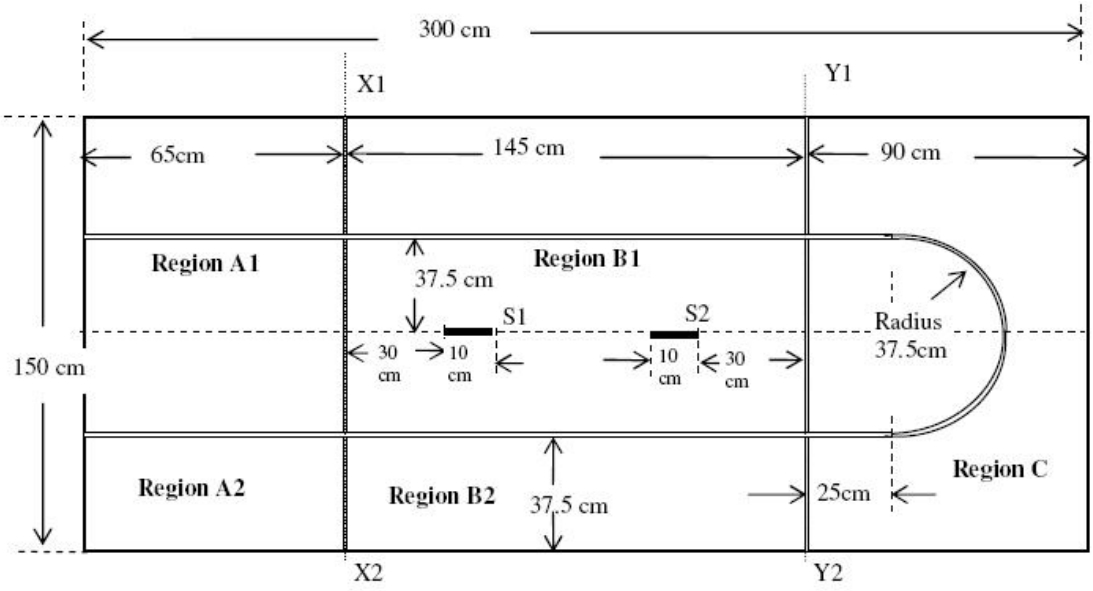

Fig.4. Pole Balancing Robot Platform

6. COMPETITION:

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

6.2 The robot may start the race from region A1 or region A2. Likewise, it can complete the race in region A1 or region A2.

6.3 If the robot is to start from region A1, the vehicle will be placed within the region A1. The handler may move the pole (the inverted pendulum) to the 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 duration of 10 seconds without the pole-support base of the robot crossing the line X1-X2 or moving beyond the centre line.

6.4 Upon completion of the above task (in 6.3 above), the vehicle should move across the line X1-X2 once, and move through the region B1 until the pole-support clears the line Y1-Y2 at least once and reach region C, without losing balance during transit, i.e. without the pole hitting any part of the table or its own chassis.

6.5 Upon completion of the above task (in 6.4 above), the vehicle must cross over to the other side of region C without losing balance of the pole. In this process it may or may not turn. It need not follow any specific path, except it should stay on the platform to the right of S2. Effectively, the robot can travel along the Y1-Y2 line or the semicircle, or any path in between.

6.6 Upon completion of the above task (in 6.4 above), the robot should travel through region B2 and move to region A2 until the pole support crosses line X1-X2. This will be counted as one cycle.

6.7 The robot may move similarly to retrace the path back from A2 through B2, C, B1, and A1. This will be counted as the second cycle and so on.

6.8 The vehicle should repeat such cycles.

6.9 The robot may end the run at either region A1 or region A2.

6.10 To count these cycles as successful cycles they must be followed by at least 10 seconds of static balancing at the region A1 or region A2 where it ends the run.

6.11 The robot may continue on **untouched** for more cycles, and *complete* them with 10 seconds of static balancing at the end, which if successful will be counted cumulatively within a total of 5 minutes of performance time.

6.12 If a robot is touched by the handler during the trial, it must be restarted for the next **attempt.** Attempts are scored separately. Scores of separate attempts will not be added, onlythe best score will be taken. Only robots with valid scores of more than 1 qualify to win a prize.

6.13 No robot will be allowed a restart after 5 minutes of performance time has elapsed.

6.14 Robot may touch the separators S1 and S2 while travelling, but should not displace them.

6.15 Robot's pole support should not cross from B1 to B2 or vice-versa using the space between S1 and S2.

6.16 Likewise robot's pole support should not cross from A1 to A2 or vice versa.

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, unless the robot is continuing the current attempt. However, the robot will be stopped after 7 minutes.

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 from start to 5 minutes, irrespective of how long the robot runs

C = 3.0, if the robot successfully completes 10 seconds of "the final static balancing" within the 5 minutes of performance time.

C = 1.5, if the robot starts "the final static balancing" within the 5 minutes of performance time, but the 10 seconds of "the final static balancing" extends beyond the performance time.

C = 1.2, if the robot continues to run beyond 5 minutes without commencing the final static balancing, but completes it with final balancing within 7 minutes. However the B-count will be limited to the number of cycles achieved within 5 minutes only.

C = 1.0, if the robot pole falls before the 10 seconds of "the final static balancing" is completed or if the pole falls during the run (with in 5 minutes limit) when the robot is in any one of the finish areas (A1 or A2)

C = 0.7, if the pole falls during the run (with in 5 minutes limit) when the robot is outside both of the finish areas.

C=0.5, if the robot continues to run beyond 5 minutes, starts final balancing and pole falls during static balancing or does not complete it within 7 minutes. B-count will be limited to the number of cycles achieved within 5 minutes only.

C=0.3, if the robot continues to run beyond 7 minutes, robot will be stopped and the B-count is limited to the cycles achieved during 5 minutes.
C=0.0, for all other cases.

Note: Referring to the scenario described in 6.11, where the robot continues the cycles **untouched** after duly completing the final balancing, in order to improve the score, it may achieve more cycles. In such cases, the additional B-cycles achieved within 5 minutes, will be weighted with appropriate C value(s).

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 ,
Singapore , 628833 .
Tel : 67478555 ,
Fac : 67467307
Contact person : Eri