POLE BALANCING ROBOT

1. DEFINITION:

Any mechanism, which supports an inverted pendulum that is free to swing around a horizontal axis with one degree of freedom, and balances it to keep it vertical by moving the point of support shall be considered "the pole balancing robot."

2. ACCEPTABLE VERSIONS:

2.1 The inverted pendulum may be supported by a vehicle moving along a straight line. Any other innovative design, which does not violate the spirit of the competition, may be allowed at the discretion of the judges subject to the following conditions:

2.2 The inverted pendulum must be free to swing. It must be balanced by moving the pivoted support point parallel to the plane of the swing. The pivot must be fixed to the vehicle.

2.3 The robot must use a standard contest balance pole specified by the organisers. A sample pole will be supplied for the institutions participating in the competition. The pole material will be aluminium.

2.4 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 the its wheels, must touch the surface of balance table. It must not fall off the competition table surface during the operation.

2.5 Balancing the pendulum/pole using any form of gyroscopic principle is not admissible.

2.6 A self-balancing design in which the pendulum will always stand up due to the use of a balance weight below the axis of rotation is also not admissible.

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

2.8 No guide rails are allowed.

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

3. POLE-SUPPORT MECHANISM AND OVERALL SIZE:

3.1. The supporting mechanism must be compatible to the diagram shown in Fig. 1. Ball bearings must be used in the axle of rotation supporting the pole, only exception being the instrumentation potentiometer or encoder. If the potentiometer or encoder is driven through gears then the gear friction must be very small as quantified in section 3.2. It must be able to swing freely from -45° to +45° from the vertical position when the vehicle is positioned in region B.

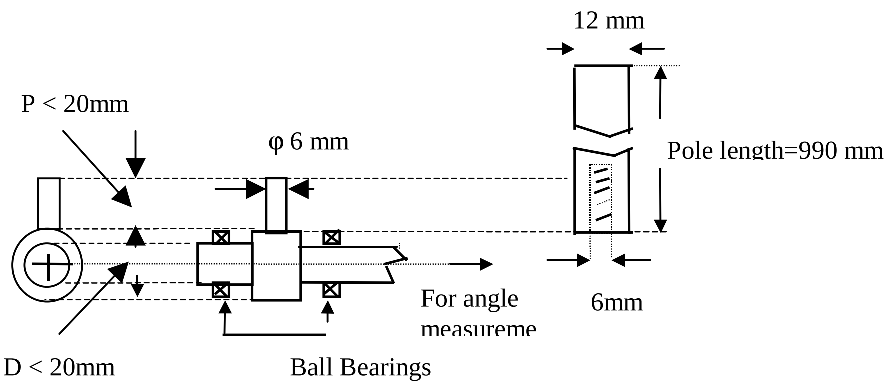


Fig.1. Pole Support Mechanism

3.2 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.

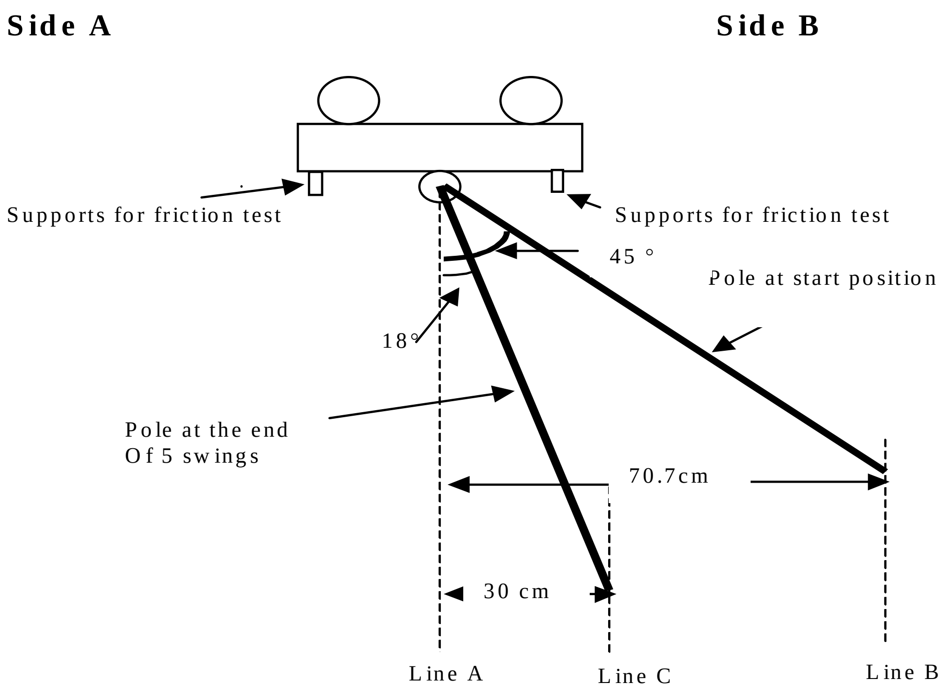
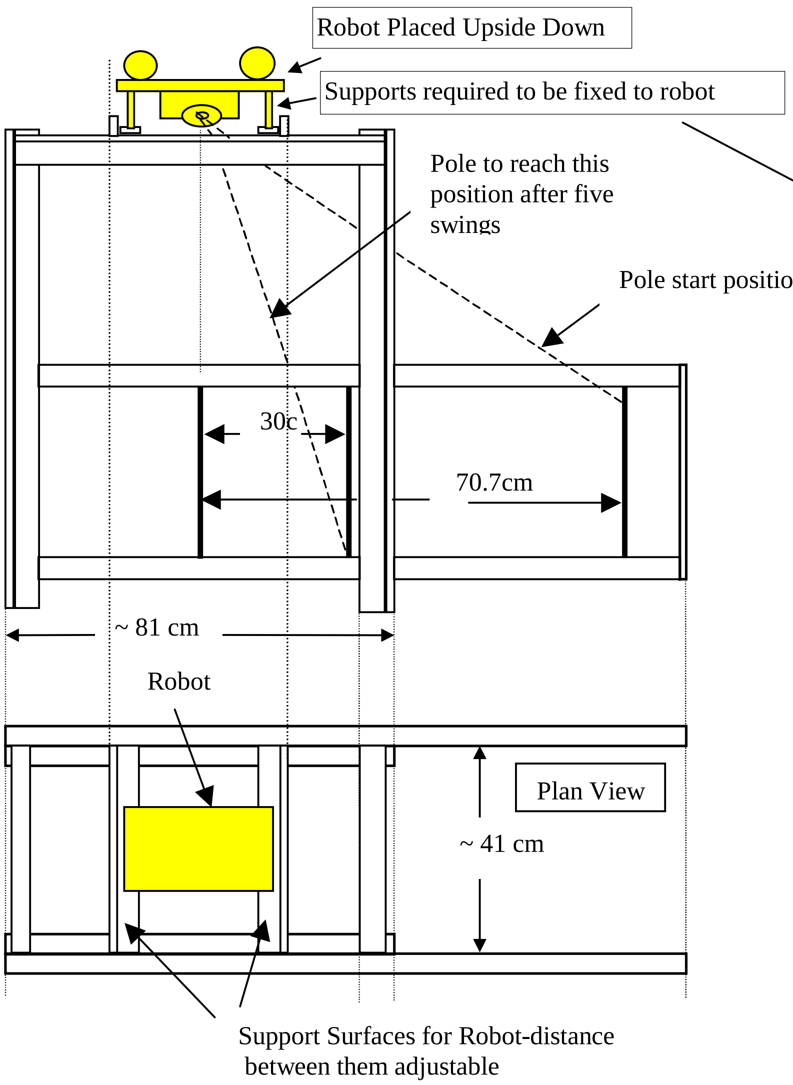


Fig.2 Friction Test Procedure with inverted Robot

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.

3.3. 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.



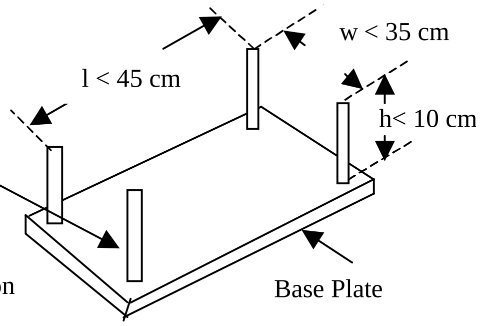


Fig.3a. Recommended attachment to the base plate (Please make sure that pole swings -45 to +45 degrees)

Fig.3. Friction Test Structure

4. TABLE:

4.1 The competition table is shown in Fig.4. One common competition table will be used by all competitors.   The gradient will be approximately 5.7 degrees. The edges between the inclined surfaces and the horizontal surface will be rounded off and there will be no joints at those edges. A neoprene rubber mat of 3mm thickness will be used on the top of the table to improve the grip of the wheels.

5. CAGING:

5.1 The robots will be caged before the competition before the friction test.

5.2. No switching of EPROMs or downloading of programs will be allowed, after caging.

5.3. Once the robot has been caged, no change of batteries will be allowed.

6. COMPETITION:

6.1. The robotic vehicle would operate on the top of the table provided. Please see Fig. 4a. The tabletop will have a slight gradient at the start (region A) and the end (region C) zones as shown in Fig. 4a.

A brass wedge of cross section shown in Fig.4b (not to scale) will be used as an obstacle. The length of the wedge will match the width of the table. The wedge will be painted to match the table surface and a retro-reflective tape will be stuck to it at the middle, to match the one on the table. The judge will place the wedge in region B anywhere between the inner edges of the two innermost tapes so that the wedge is perpendicular to the path. It will not be moved thereafter.

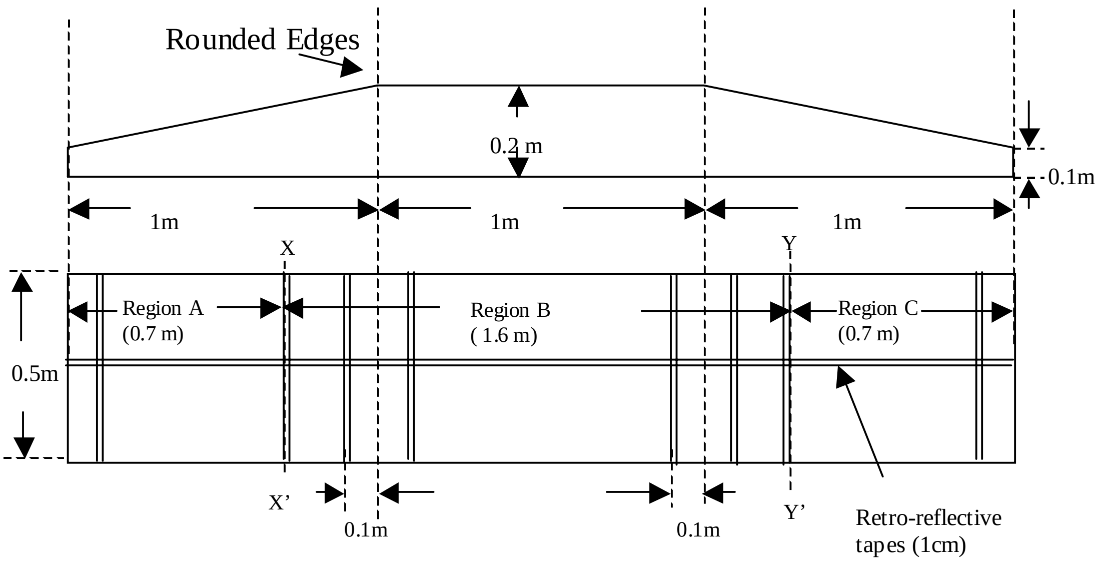


Fig.4.a. Pole Balancing Robot Table

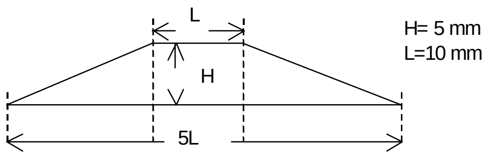


Fig.4.b.Wedge Section
(enlargded view)

6.2. The vehicle will be placed within the region A (see Fig. 4b). 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. The vehicle should repeat these cycles.

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

6.7. 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.

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

7. NUMBER OF ATTEMPTS:

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 does less than 20 seconds of initial static balancing
A = 1 if the robot completes 20 seconds of 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= 0.0, 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.

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