

## WALL CLIMBING ROBOT RACE

### 1. OBJECTIVE

The aim of this event is for mobile robots to demonstrate their horizontal and vertical surface climbing abilities during a race.

### 2. THE COMPETITION ENVIRONMENT

- 2.1 The wall is shown in Figure 1 below. It consists of three sections: a 2 metre long horizontal section (section A) on the ground followed by a 2 metre high vertical section (section B) followed by a 2 metre long horizontal section (section C) at the top, with each section 1.2 metres wide.

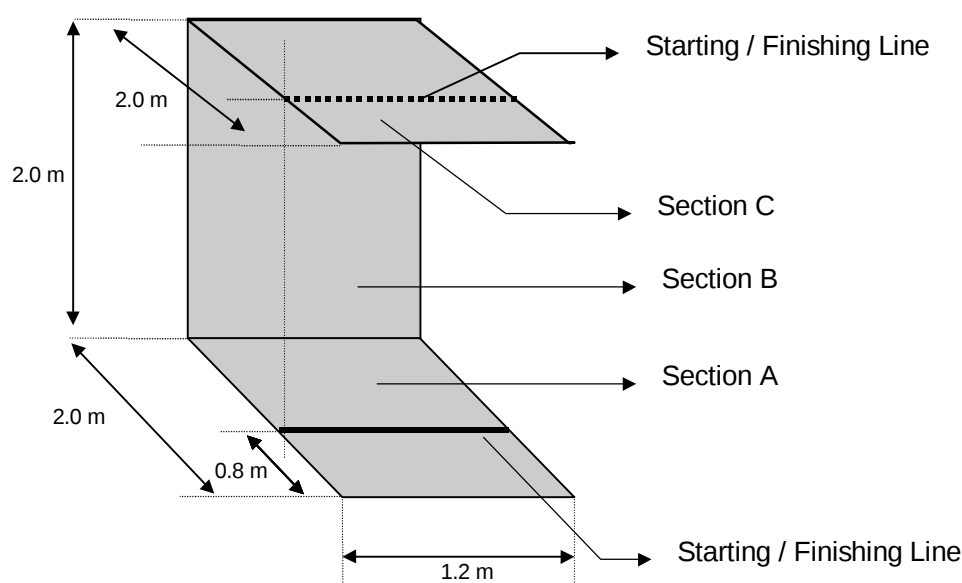


Figure 1: The wall for the wall-climbing robot race

- 2.2 The surface of the wall will be covered with mild steel sections with a thickness of at least 0.003 metres. The wall will have a matt black surface finish.
- 2.3 Starting / finishing lines will be located 0.8 metres from the beginning of the horizontal section on the ground (section A) and 0.8 metres from the end of the top horizontal section (section C). The line in section A will be used to demarcate the maximum size of the robot.
- 2.4 The supporting structure for the wall will have provision for *two* safety cables to be attached to the robot so that both cables can be used simultaneously during the race (*not* shown in Figure 1.)
- 2.5 The wall sections A and B will each have one obstacle consisting of a horizontal bar made of non-magnetic material (not shown) with 0.03 m X 0.03 m square cross-section will be placed laterally across the entire width the section. Both of these obstacles will be placed such that one of its sides is touching the wall section. Both of these obstacles will have reflective tape fully covering the exposed sides of the obstacle. The obstacle across wall section A will be placed randomly such that it is at

least 0.5 m away from the edge where it meets the next wall section (wall section B) and also at least 1.0 m from the opposite edge. The obstacle across section B will be placed randomly such that it is at least 1.0 m from the edge that meets the lower wall section (wall section A) and at least 0.5 m from the edge that meets the upper wall section (wall section C).

- 2.6 The wall structure will be constructed such that it conforms to the following:

- (a) the length of each wall section should be  $2000 \text{ mm} \pm 5 \text{ mm}$ .
- (b) the angle formed between two adjacent wall sections should be  $90^\circ \pm 0.5^\circ$ .

The wall will be deemed to have satisfied criteria (a) and (b) above and be considered fit for use if each of the two distances between diagonally opposite corners (using the side view in Figure 1) lies in the range 2733 mm to 2847 mm.

### 3. THE COMPETITION

- 3.1 Robots will start from a stationary position anywhere before the starting line on the horizontal section (section A) on the ground.
- 3.2 On reaching the vertical section (section B) the robots will attempt to climb up the vertical section and subsequently climb 'upside-down' to the end of the top horizontal section (section C.) On reaching the end of the top horizontal section, the robot will attempt to return to the starting point by climbing back through sections C, B and A in sequence. The sequence of wall sections to be climbed from start to finish is A-B-C-C-B-A.
- 3.3 The robot that completes the highest number of wall sections in the sequence according to paragraph 3.2 above wins.
- 3.4 In the event that two or more robots complete the same number of wall sections, the scoring system based on the formula described below will be used. This scoring system awards points so that the robot that completes either the entire course or the highest number of wall sections in the sequence described in paragraph 3.2 above (in the event that there are no robots that can complete the entire course) in the shortest time wins. The robot that scores the highest number of points according the following formula wins:

$$\text{Score} = 200 \times W - T + R + S$$

where  $W$  = The number of wall sections completed by the robot *excluding the first time it completes the wall section A*, in the sequence according to paragraph 3.2 above.

$T$  = The time taken (in seconds) by the robot to complete  $W$  wall sections.

$R$  = A bonus of +50 to be awarded if the robot demonstrates a minimum degree of consistency in performance by successfully completing the entire course of all wall sections in the sequence according to paragraph 3.2 above in each run on at least two consecutive runs made during the race without falling off the wall.

$S$  = A bonus depending on the extent that the robot is self contained (autonomous). To be eligible for the bonus,  $S$ , the robot must successfully complete the entire course of all wall sections in the sequence according to paragraph 3.2 above at least once during the

race without falling off the wall. The bonus, S, will be awarded according to the table below:

| <b>Type of Robot</b>                                                                                              | <b>Bonus</b> |
|-------------------------------------------------------------------------------------------------------------------|--------------|
| 1. Totally self-contained robot with internal power source and internal automatic-control / intelligence.         | +400         |
| 2. Partially self-contained robot with external power source and internal automatic-control / intelligence.       | +200         |
| 3. Robot with both external power source and external automatic-control / intelligence.                           | +100         |
| 4. Human controlled wall climbing mechanism with internal or external power source that requires manual control . | 0            |

*Note: The bonuses R & S both apply to the best score obtained by the robot during the race.*

- 3.5 A robot is deemed to have started once any part of the robot crosses the starting line in the wall section A.
- 3.6 A robot is deemed to have completed its climb through a particular wall section when it fulfils all of the following conditions (a), (b) and (c) *in sequence*:
- (a) the robot touches the wall section that it is about to complete
  - (b) the robot simultaneously touches both the wall section that it is about to complete as well as the next wall section in the sequence of wall sections that is consistent with its direction of travel
  - (c) the robot ceases to touch the particular wall section that it is about to complete and touches the next wall section in the sequence that is consistent with its intended direction of travel.

The above conditions apply to all wall sections except in the following cases:

- (i) when the robot completes its climb through the wall section C *for the first time* in the sequence according to paragraph 3.2 above
- (ii) when the robot completes the last wall section (wall section A) in the sequence according to paragraph 3.2 above;

In both cases (i) and (ii) above, the robot is deemed to have completed its climb through the wall section only when the entire robot has crossed the finishing line placed within that particular wall section.

- 3.7 Once the race begins, each team of participants will be given a maximum of 10 minutes to produce its best result. *No* extra time will be given at the beginning for participants to set-up or prepare their robots.
- 3.8 After the race begins, any physical handling of the robot such as touching, pulling of cables or pushing of the robot during a climb will disqualify the result of that climb. However if a robot falls off while climbing the wall, using the safety cables to break the fall of the robot is allowed and the result of the climb will be determined as specified in paragraph 3.3 & 3.4 above.
- 3.9 During the first two minutes of the 10-minute race, participating teams may seek permission from the judges to temporarily withdraw because of technical difficulties

and re-enter the race at a later time. If a participating team is allowed to re-enter the race then it will have a reduced time of 5 minutes both to prepare their robot for action and to produce its best result at the same time. All race results obtained by the robot previously before the temporary withdrawal will *not* be considered. Permission to temporarily withdraw from the race and re-enter at a later time will not be automatically granted and the judges will use their discretion in granting permission on a case-by-case basis. Each participating team may only temporarily withdraw and re-enter the race once.

#### **4. THE ROBOTS**

- 4.1 The dimensions of each of the competing robots must *not* exceed 0.75 metres in length, width and height *at all times* while the robot is in operation. For non-autonomous designs these dimensions apply for the mobile or climbing part of the robot only.
- 4.2 The weight of each of the competing robots must *not* exceed 10 kilograms. For non-autonomous designs this weight restriction applies to the mobile or climbing part of the robot only.
- 4.3 Competing robots must not have parts removed or added to them during the competition except for replacement of batteries or for repairs essential to the operation of the robot. The competing robots are not allowed to discard any part of their chassis during operation. The competing robots must not use chemical or combustion power methods.
- 4.4 The competing robots must not damage the competition environment including the wall and its supporting structure and the sensors in any way.
- 4.5 The competing robots must not endanger the judges and the spectators in any way. All competing robots must be firmly secured with two safety cables at all times during operation.
- 4.6 A robot will be disqualified during the competition if it endangers the judges, the participants or the spectators in any way during the competition, or if it damages the competition environment. Alternatively a robot may be banned from competing if, in the opinion of the judges, it is likely to pose a safety hazard or cause damage to the competition environment.

#### **5. CLONING**

- 5.1 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.
- 5.2 Clones will be identified by the working principles of the whole robotic system, such as the sequence of operations during the crossing of obstacles and negotiating the wall bends.
- 5.3 When in doubt, the decision of the Judges will be final.