

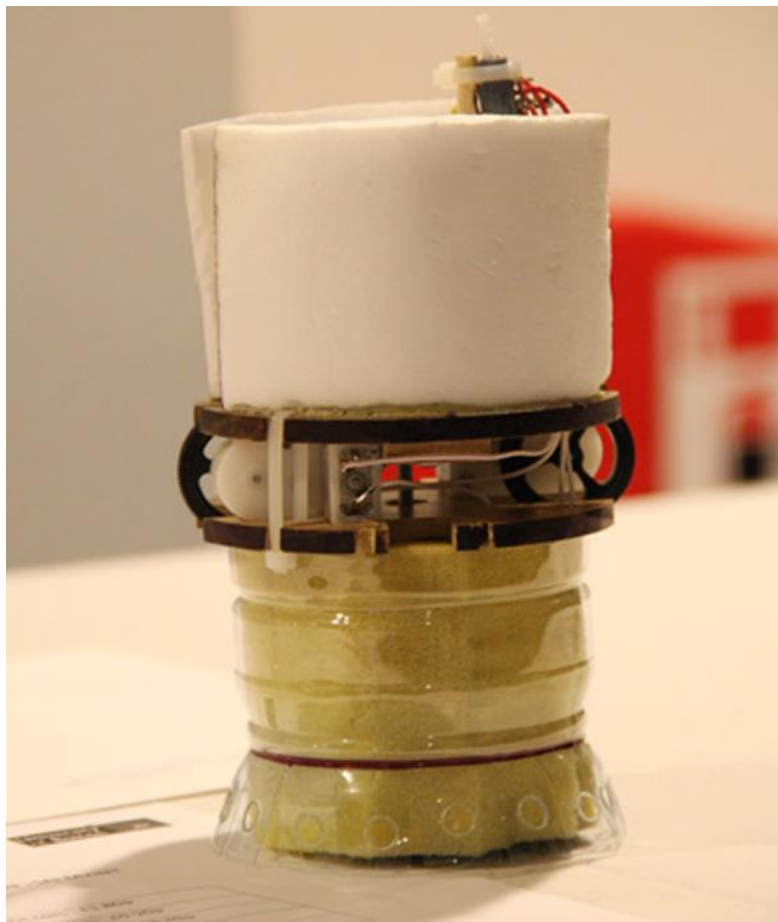
# DESIGN CHALLENGE

# PROJECT SPECIFICATION AND RULES.

Institution of  
**MECHANICAL  
ENGINEERS**

IMechE 2nd YEAR DESIGN CHALLENGE 2018

INTERNAL PIPE CLIMBING DEVICE



**Internal Pipe Climbing Device**  
**IMechE 2<sup>nd</sup> Year Undergraduate**  
**Design Challenge 2018**

*Note: This Specification must be read in conjunction with the IMechE 2nd Year Design Challenge General Specification - Iss 2.1*

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# 1. Introduction

This year the challenge is to design, build and test a device to climb up and down the inside of a piece of vertical transparent tube. The 'device' can be of any construction and propulsion method, limited only by cost, and size, within the specification detailed below. The competition encourages the use of sensors and control systems, to operate a device, which must:

- be capable of lifting an increasing load
- complete two and a half cycles travelling up and down the tube
- pause for between 5 and 10 seconds at the mid-point of both the climb and descent on the second cycle
- stop accurately at the mid-point on the final climb
- be started manually, but once it has done so, no interference or outside control is allowed

The increasing load will be in the form of a chain, where the weight of chain to be lifted is specified as 0.17 kg/m.

The two and a half cycles will consist of five phases, as shown in Figure 1 below:

- Phase 1: All the way up, with no requirement to stop at the target
- Phase 2: All the way down, with no requirement to stop at the target
- Phase 3: Up, with a 5 - 10 second pause at the target, and then continuing up to the top
- Phase 4: Down, with a 5 - 10 second pause at the target, and then continuing down to the datum line
- Phase 5: Up, and stop at the target to complete the challenge

In the spirit of the competition, it is expected that the device be designed, developed and manufactured by students within the facilities of their university. Any member of the team should have a good understanding of the design principles, theories, manufacturing methods and materials used.

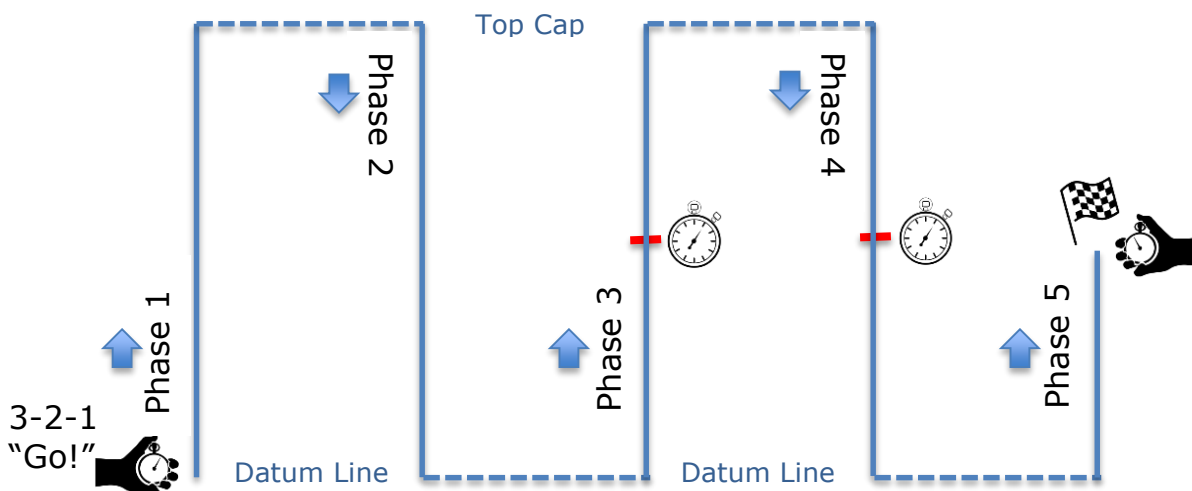


Figure 1: The Five Phases of the Internal Pipe Climbing Challenge.

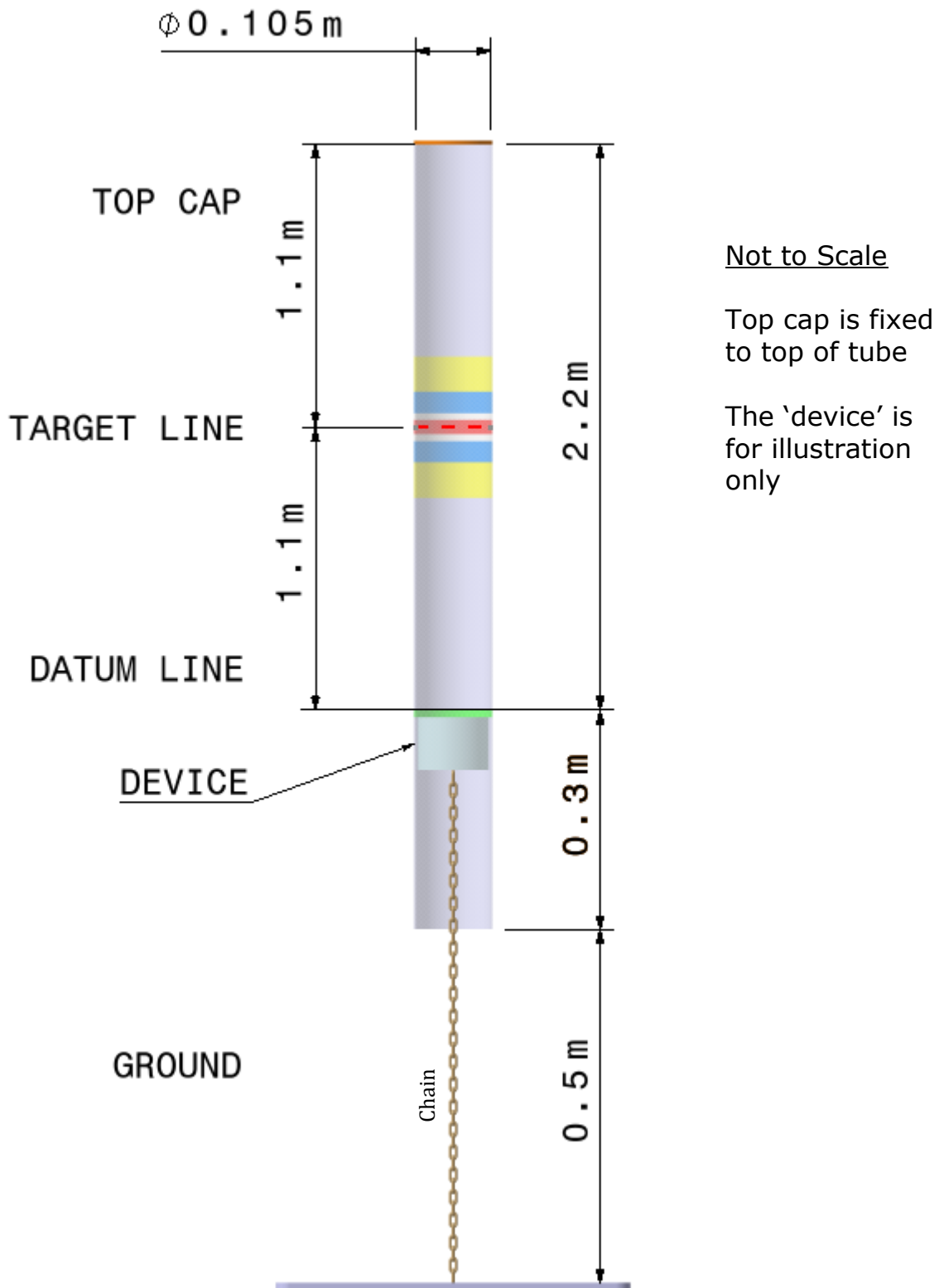


Figure 2: The Internal Pipe Climbing Device and Test Rig.

## 2. Technical Regulations

2.1 The device can be of any type, but it must be self-contained and at all times during the competition fit within a tube of internal diameter 0.105m and length 0.3m. Nothing used by the device for control, or movement, can be outside the specified volume during the race (no remote control, power leads, left behind markers, etc.)

2.2 The test area will consist of up to four identical tubes to allow for parallel runs. Each tube is made from PVC-U, has an internal diameter of 0.105m and is 2.5 m long.

2.3 Controlling devices, whether by discrete components, or devices such as an Arduino, should be mounted on the device and kept within the specified volume at all times.

2.4 No proprietary, pre-programmed control units may be used. Programming details should be shown in the device brochure.

2.5 Each device must have a quick and simple method of attaching and detaching the chain, which should not require the use of tools. It is up to individual teams as to how this is achieved, but any coupling must not cause the device to violate the dimensions shown in Figure 1. Failure of the attachment or loss of the chain will result in disqualification from the heat.

2.6 The vehicle may use any form of propulsion available within the cost limit. Propulsion systems may not include explosives or combustion.

2.7 The position of the device relative to the mid-point target and datum line will be determined relative to the upper surface of a datum disc, which forms the top surface of the device. The datum disc must be a flat, round disc of at least 90mm diameter and no less than 3mm thick.

2.8 Only switches and sensors used for controlling the device may protrude above the datum disc. They must be kept within the specified volume and be below the datum line at the start.

2.9 No adhesive or lubricant is to be used between the device and the tube. Devices must not cause any damage or leave any debris on the internal surfaces of the tube.

2.10 Details of the pipe and chain suppliers, including part references, can be found at the following links:-

<http://www.ipsflowsystems.com/pdfs/pvcu/pvcuclear.pdf>  
[http://www.diy.com/departments/side-welded-steel-chain-3mm-x-2m/1267464\\_BQ.prd?icamp=recs&rrec=true](http://www.diy.com/departments/side-welded-steel-chain-3mm-x-2m/1267464_BQ.prd?icamp=recs&rrec=true)

Please note that the above suppliers are not mandated. These references are included only for those Universities that are unable to purchase these items from existing approved suppliers.

2.11 The target area will be marked using a sticker or transfer as shown in Appendix C. The datum line will be marked with tape or a sticker. The exact colour and opacity of tape, stickers or transfers cannot be guaranteed.

### 3. Competition Rules

3.1 Teams will compete head to head in heats for a place in the Regional final. The relative performance will be determined by teams accumulating points during a run. Points will be awarded for successfully completing phases of the challenge and hitting the mid-point target accurately.

3.2 The time limit for the heats and final will be three minutes. Time will start from the end of the timekeeper's starting countdown. A maximum one minute setup time will be permitted between each attempt.

3.3 Heats will consist of up to four devices running in parallel. Each team must compete in all three heats. Scores will be recorded for each successful attempt.

3.4 The device must make contact with the top cap after the upward travel phase and before downward travel on each cycle.

3.5 The device datum disc and switches or sensors must clearly reach below the tube datum line after the downward travel phase and before the upward travel on each cycle.

3.6 During phases 3 and 4, the device must pause for between 5 and 10 seconds when it reaches the mid-point target. This rule is to allow the judges time to check the accuracy of the device relative to the target.

3.7 The "Device Controller" is allowed to hold their device in position up to or below the datum line (0.3m above the bottom of tube) before starting. The teams competing in a heat will be required to start their devices simultaneously. Once started, there can be no outside interference. Having started their device the Device Controller must then step away from the tube.

3.8 During a run all team members must be outside the test area. A judge will be allocated to each test area to ensure the correct procedure is followed.

3.9 Repairs and minor alterations to the vehicle between the single runs in each heat are allowed.

3.10 It is permissible to replenish the device's energy source between testing. Competitors should consider this during their design process so as to minimise disruption to the smooth running of the event. Any team not ready to compete within three minutes of being called will be disqualified.

3.11 The top four teams (or top three teams if there are less than four tubes on the competition rig) in the heats returning the highest scores and meeting the specification requirements will progress to the final. A record of performance of each group will be recorded using the table shown in Appendix A.

3.12 If a device fails to operate and the team has completed at least one run, the result will be used as their highest score recorded, provided they attempt to compete in all other heats.

## 4. Scoring

4.1 The winner will be the team that accumulates the most points in attempting the challenge.

4.2 Points will be awarded for phases that are completed successfully and as shown in Figure 3.

Points	Description
1	Starting successfully
2	Passing the mid-point
3	Reaching the top
4	Starting the descent
5	Passing the mid-point
6	Crossing the datum line
8	Starting the climb
10	Reaching the top
12	Crossing the datum line

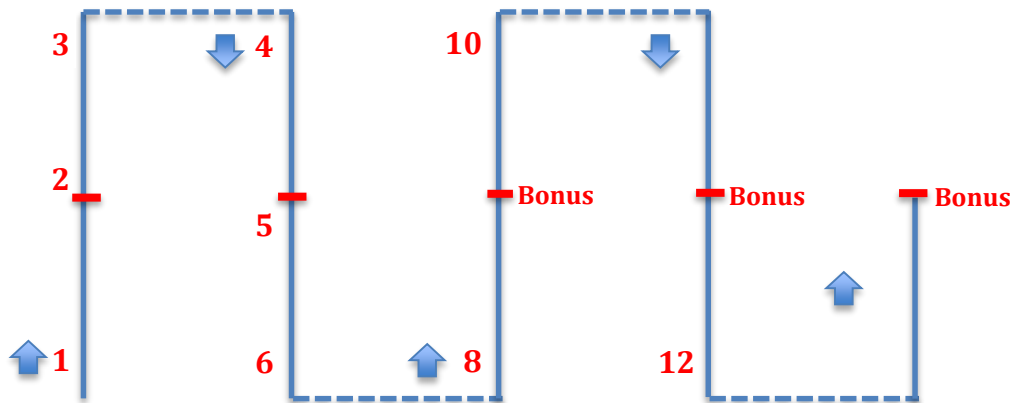


Figure 3: Scoring.

4.3 Bonus points will be awarded for devices that stop accurately on the mid-point target on phases 3, 4 and 5 as follows:

- within  $\pm 10$  mm will score 10 points
- within  $\pm 20$  mm will score 8 points
- within  $\pm 50$  mm will score 4 points
- within  $\pm 100$  mm will score 2 points

The scoring zones are shown in Appendix C.

4.4 If the device comes to rest in the target area, such that the datum disc is at an angle breaking two scoring zones, then the higher score will be recorded.

4.5 Devices that pause, but for less than the minimum 5 seconds, or more than the maximum 10 seconds, at the mid-point target on phases 3 and 4, will not receive any bonus points.



4.6 No score will be recorded under the following circumstances:

- if the device has not come to a stop after three minutes,
- if the device, or its team, does not comply with the competition rules, or
- if the device does not stop within the target area ( $\pm 100$  mm) around the mid-point target on phase 5
- if the device falls out of the tube

4.7 A device, disqualified from one of its attempts can still take the other attempts.

4.8 In the event of a tie affecting qualification to the final or placing in the final, the tied devices will be retested in head-to-head heats until a winner is found. In the unlikely event that a winner cannot be determined after three attempts, the lightest device will be the winner.

4.9 In the unlikely event of there being a technical fault to the test apparatus (not devices) deemed to unfairly disadvantage a team, there will be a rerun. For any tie after a rerun, the lightest device will be designated the winner.

Appendix A

Record of Performance Template - Heats

TEAM	HEAT 1					HEAT 2					HEAT 3					RESULT	
	SCORE	BONUS POINTS			TOTAL	SCORE	BONUS POINTS			TOTAL	SCORE	BONUS POINTS			TOTAL	GRAND TOTAL	RANK
		Phase 3	Phase 4	Phase 5			Phase 3	Phase 4	Phase 5			Phase 3	Phase 4	Phase 5			

## Record of Performance Template

TEAM	HEAT 1				
	SCORE	BONUS POINTS			TOTAL
		Phase 3	Phase 4	Phase 5	

## Appendix B

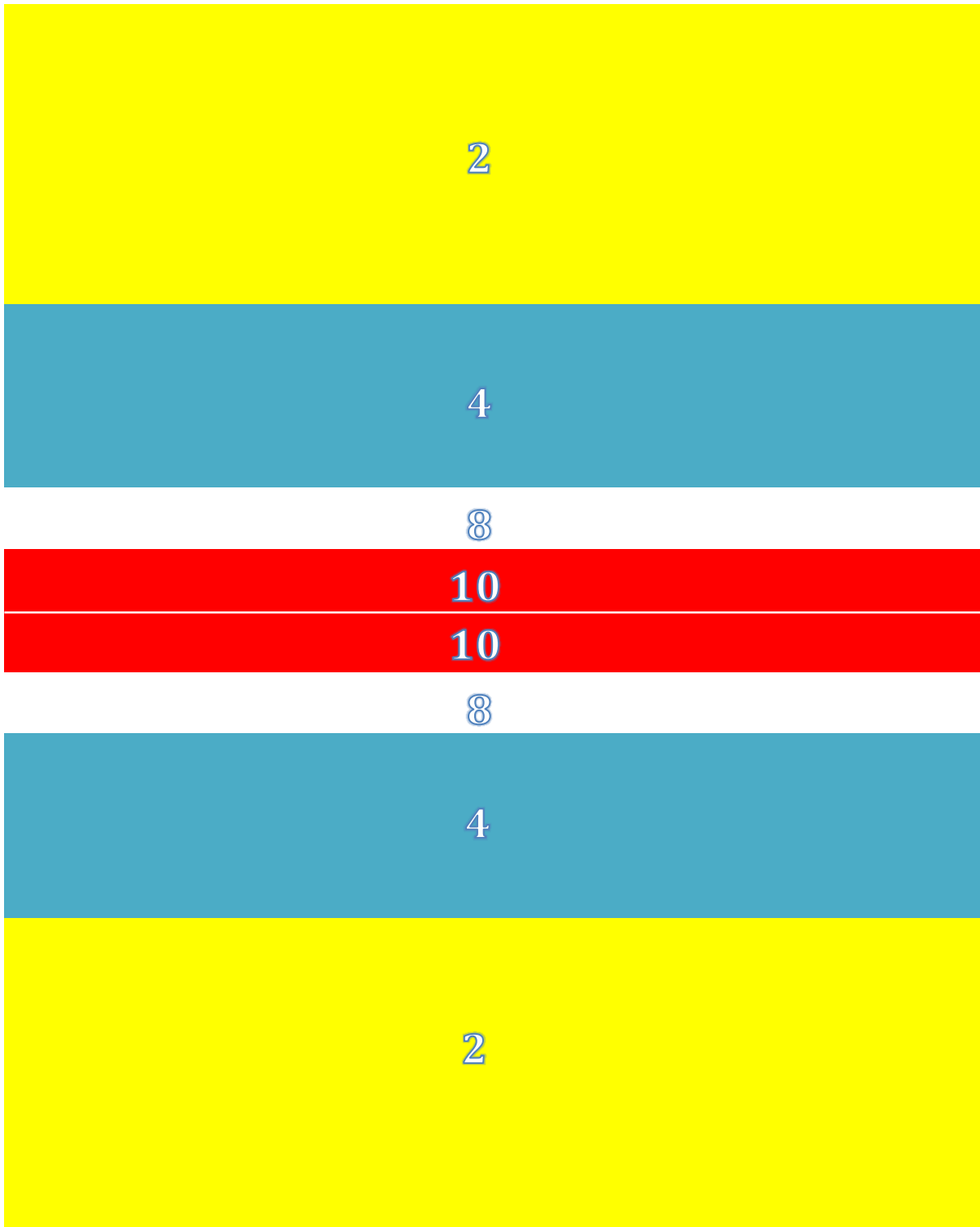
Procedure for each run:

A judge will be allocated to each competition pipe to ensure the rules are adhered to and use a digital stopwatch to manually time that pipe's device on its run.

A further judge will start and oversee each heat, then declare the finishing order for that heat.

1. Teams put forward their devices with a nominated "Device Controller".
2. The Device Controllers put devices in the tubes with the datum disc aligned with the tube datum line.
3. Judges check device starting positions.
4. The Device Controller from each team will start that team's device manually on completion of a countdown given by a single timekeeping judge ("Three-two-one-GO!"). There may be a random wait between "one" and "GO".
5. False starts in any run will not trigger a re-run; any team judged to have started before the "GO" signal will be disqualified from that run.
6. Having started the team's device, each Device Controller must then step away from the test area.
7. The attempt ends when a device has stopped.
8. During a run, judges will determine scores and bonuses from the scoring rings around the mid-point target.
9. At the end of each device's run, the Device Controller must safely disable the propulsion system.
10. Teams collect devices when authorised by the judges. Minor repairs and adjustments can be made at this stage.
11. The organisers will record scores and resolve ties efficiently, so as not to interfere with the smooth running of the event.

## Appendix C



*The Scoring Zones Around the Mid-Point Target (Scale 1:1).*

*If printed 1:1, this page can be used to create transfers for sticking on the tube.*

## List of Amendments:

Iss	Page	Details	Date
1.0	-	Released for approval	28.08.2017
2.0	4	1. Introduction	12.09.2017
	7	Wording to Phases 1 - 4 updated	
	8	3. Competition Rules Items 3.1, 3.2, 3.3, 3.11 & 3.12 revised	
	10	4. Scoring was 'Timing' Revised for points scoring, not timing New Figure 3 added for scoring Appendices revised	
2.1	-	Pause now between 5-10 seconds	14.09.2017
	6	2.8 Amended to clarify position of sensors at the start	
	7	2.11 Added to clarify the use of stickers and transfers	
	8	3.5 Amended to clarify sensors must reach below the datum line	
	8	Section 4 item numbering corrected	
	9	4.6 Requirement to stop on Phase 5 removed	