2nd YEAR DESIGN CHALLENGE
PROJECT SPECIFICATION AND RULES 2020

IMechE 2nd YEAR DESIGN CHALLENGE
LINE LAUNCHER
Project Specification for the 2020 Line Launcher 2nd Year Undergraduate Design Challenge

Key HQ Contact: Jelena Gacesa, Operations Manager – Education Programme

Jelena.Gacesa@IMECHE.org

designchallenge@imeche.org

Tel: 020 7304 6867

Note: this specification must be read in conjunction with the document “IMechE 2nd Year Design Challenge - General Specification 2020” available on the IMechE Design Challenge website.
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1. Introduction

The Design Challenge, organised by the Institution of Mechanical Engineers, is an annual competition for students in their second year of study on an undergraduate engineering degree programme. The Challenge comprises four parts, all of which are detailed later in this specification.

This year the challenge is to design, build and test a device to simulate a line launcher. Such a device is used to fire a rope from one ship to another at sea, or for various other rescue scenarios. For instance, delivering a line to a high-rise building, or pulling a zip line over a divide.

Figure 1: A Line Launcher

The challenge is for teams to produce a small-scale indoor device, to fire a squash ball attached to a line, at a vertical target, from various distances. The design will principally deal with energy storage and projectile trajectory from a fixed point. Teams are encouraged to consider that there are many methods of firing projectiles; such devices require a controlled and safe method of energy storage with a reliable release mechanism.

The ‘device’ can be of any construction and propulsion method, limited only by cost, and size, within the specification detailed below. However, the device must be totally self-contained, and once programmed, must have no other means of external control, except for a launch switch. Full details are given later.

The device must be loaded manually, before being automatically energised, and the ball launched. This means that from the point of loading, the device must be fully autonomous. The launch sequence must be triggered using a remote switch. When pressed, the device must independently energise the launching mechanism and set the elevation for the correct trajectory to hit the chosen target. No manual intervention is allowed, except for loading and aligning the device horizontally.

At a given range, a full launch sequence involves delivering three balls to three targets at different heights. Any programming required must be completed before the sequence starts. Between each shot, the launcher must be returned to a safe ‘neutral’ position and reloaded manually. No programming of the device is allowed during the launch sequence. The only control allowed is to use the remote switch for initiating each ball launch. All three shots must be completed within a time limit.

Points will be awarded for the accuracy of the device based on the ball successfully hitting the target.

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.
Note: this specification must be read in conjunction with the document “IMechE 2nd Year Design Challenge – General Specification 2020” available on the IMechE Design Challenge website.

2. Competition Conditions

To simulate a rescue line launch, a firing range (Figures 4 & 5) will be set up in an indoor space. The minimum ceiling height will be 3m. Devices will fire balls from a launch platform at three targets of different sizes and at different heights. Full dimensions and the scoring zones are shown in Figure 6, with the target heights in Figure 5. The target board will be vertical, and the launch platform horizontal, noting that surfaces will be flat and level within normal building tolerances. Consistency amongst heats will be maintained within the spirit of the competition.

A launch location pin will be attached to the base of the launch platform. The location pin is mounted at the centre of a 600mm x 600mm table, which forms the launch platform. The location pin is an M10 bolt, 50mm long with 35mm of thread exposed above the surface of the launch platform. Devices are to be secured to the location pin using a 10mm washer and wing nut, which will be provided at the competition. Clear access to the wing nut is required to enable the launcher to be easily secured and removed without disassembly.

![Launch location pin with securing washer and wing nut.](image)

Range is the horizontal distance from the centre of the launch location pin to the front face of the target. Scoring will be judged by the aperture the ball passes through on the target.

The launcher must fire a yellow dot squash ball, which is attached through its approximate centre to a line by the method shown in Figure 3. A similar loop at the opposite end must be used to attach the line securely to the device. Balls and lines will be provided at the event with the length of line approximately 8m, sufficient to prevent the line length becoming taut and thus controlling range. Excess line cannot be added, cut off, or tied to a specific length.

Full drawings and dxf files will be available to organisers for making the competition rigs. Examples of suppliers for all the equipment and materials are given in Appendix 1.
Figure 3: Line attachment to a yellow dot squash ball (loop slackened for clarity).

Figure 4: The Line Launcher Target Layout.
**Figure 5: The Line Launcher Major Dimensions.** All tolerances ±10mm unless otherwise stated. Angular tolerances ±5°.
Figure 6: Target Dimensions and Scoring Zones.
All tolerances ±2mm unless otherwise stated.
The Launch Sequence – See Sections 6 & 7 for Further Details

3 Minute Warning

Complete Device Programming

Manual Mounting of Device to Launch Platform
Manual Horizontal Alignment Allowed

Tighten Wing Nut

Manual Set Device to Neutral Position

Green Light Illuminates

No More Programming Throughout the Launch Sequence

Start of Firing Sequence

Manual Load Ball 1

2 Minute Time Limit Starts

Launch Sequence Can Now Be Activated

Red Light Illuminates

No Manual Intervention Until Device Returns to Neutral Position

Autonomous Operation Only Until Ball Has Fired

Energise / Set Trajectory / Fire Ball
Return to Neutral Position (Manual or Autonomous Operation)

Green Light Illuminates

*End of Firing Sequence*

The Firing Sequence Can Now Be Repeated for Balls 2 & 3

**STOP!**

2 Minute Time Limit

The time limit is for firing all three balls
### 3. Rules for the Design Challenge Competition

3.1 Each team may have up to five students

3.2 There are four competition elements to the Design Challenge. The format of the Regional Competition and National Final is as follows:

<table>
<thead>
<tr>
<th>Regional Competition</th>
<th>National Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poster</td>
<td>Poster</td>
</tr>
<tr>
<td>Presentation</td>
<td>Presentation</td>
</tr>
<tr>
<td>Peer Review</td>
<td>Design Excellence</td>
</tr>
<tr>
<td>Line Launcher Competition</td>
<td>Line Launcher Competition</td>
</tr>
</tbody>
</table>

3.3 All teams must compete in all sections of the competition.

3.4 Points will be given for all sections of the competition.

3.5 Points will be awarded for the heats and final of the Line Launcher Competition.

3.6 For the Regional Competition there will be winners for each of the competition elements.

3.7 For the National Final, all the points scored for each section of the competition will be totalled to determine an outright champion.

<table>
<thead>
<tr>
<th>Poster</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentation</td>
<td>10</td>
</tr>
<tr>
<td>Design Excellence</td>
<td>10</td>
</tr>
<tr>
<td>Line Launcher Competition</td>
<td>120</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>150</strong></td>
</tr>
</tbody>
</table>

3.8 In the National Final, in the event of a tie of overall points after the competition final, the team with the highest points in the Line Launcher Competition will be the champion.
4. Prizes.

In the Regional Competition, the winning University of the Competition will receive the Regional Design Challenge Trophy to keep for one year, or until the next Regional competition, and a certificate. All members of the winning team will receive a certificate.

In the National Final, the winning Region (University) will receive the prestigious Design Challenge Trophy to keep for one year, or until the next National competition, and a certificate. All members of the winning team will receive a replica trophy to keep, together with a certificate.

Certificates will be available for the following in both regional and national finals:

The runner up team.
The third placed team.
The winning team of the Presentation Competition.
The winning team of the Poster Competition.
The winning team of the Peer Review (Regional Competition).
The winning team of the Design Excellence Competition (National Final).
All members of the other participating teams will receive certificates.

Certificates will only be awarded to participating team members and not to team supervisors or university staff members.
5. Sponsor Awards

In addition to the IMechE prizes, the following awards will be made by the competition sponsors:

**Autodesk `Design & Make` Award**

The use of advanced technology from design to manufacture will be essential throughout the IMechE Design Challenge.

In the Regional Competition, prizes will be awarded to the team which demonstrates the most innovative use of advanced technology found within Fusion 360, i.e. Generative Design. This would most likely make the form of a manufactured component that adds significant value in terms of performance, light weighting, or parts consolidation, to the final solution.

Teams are free to demonstrate their designs using appropriate means during the day. A representative from Autodesk will judge all the entries based on the quality of CAD, CAM, CAE work, the level of technical detail, and how well it enhances the viability of the actual device.

In the National Final, Autodesk will award the winning team a trophy and certificate, as well as an experience visit to their Birmingham Technology Centre. The winning team will also be invited to present their solution at Autodesk University in London, and their European event in Barcelona. Transportation and accommodation costs will be covered.

Further details on Autodesk and their products, including their Fusion 360 design and engineering software, can be found by clicking here. Autodesk offer their entire suite of software free to students.

**Mashoom Design Management Award**

Following a clear process and documenting the design is very important when manufacturing is involved. Drawings and parts should all have a unique identification number and changes to designs should be traceable by issue numbers and revisions.

In the Regional Competition, certificates will be awarded to the team demonstrating the best management of their design data. Teams are free to showcase their project management and design process using appropriate means during the day. A representative from Mashoom will judge all the entries based on the quality of the design and manufacturing data used and how this has been documented throughout the process.

In the National Final, Mashoom will award the winning team a trophy, in addition to the certificates.

Further details on Mashoom and their products, including their CAD data storage, version control and management software can be found by clicking here. Mashoom offer their entire package free to students.

*Please note that the Sponsor Awards are not a formal, or obligatory, part of the competition. The requirements for these awards have no bearing on the competition itself.*
6. Technical Regulations for the Line Launcher

6.1 The device can be of any type, but it must be totally self-contained, and at all times during the competition fit within a working envelope of 400mm x 400mm x 400mm. On the day of the competition this will be checked using a gauge.

6.2 The device must fit within the maximum working envelope at all times during competition, even during firing.

6.3 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.

6.4 No proprietary, pre-programmed control units may be used.

6.5 The device may use any form of propulsion available within the cost limit. Propulsion systems may not include explosives or combustion. Devices must be regarded as safe and reasonable and conform with the General Specification as judged by the member of staff responsible for the team. Consideration should be given to guarding if there is risk of entanglement or entrapment.

6.6 The device must sit above and not overhang the edges of the launch platform.

6.7 Parts from existing firing devices (i.e. triggers, barrels, breaches) are not permitted.

6.8 All devices must be fitted with a mechanical locking safety device which can be used to prevent the ball being accidentally fired once armed. As an example, this may be a pin that can be inserted to prevent the device from launching.

6.9 All devices must also be fitted with an automatic energy safety mechanism that will de-energise the launcher should it malfunction. This function should be a reverse of the energising process and not a sudden release of energy, as experienced during a launch.

6.10 The energy safety mechanism must be operated by a mechanical single pole, single throw switch, commonly known as a two-position switch. It must be red in colour. The switch must be located on the centre line at the rear-most point of the device and be mounted securely to the base of the device. It must not be obstructed at any time during the launch sequence and must remain within the specified working envelope at all times.

6.11 The locking and/or energy safety mechanisms must be operated on the instruction of a judge if there is any doubt about the integrity of the device during the launch sequence.
6.12 Safe operation of the locking and energy safety systems must be proved during scrutineering. Devices that fail this inspection will not be allowed to compete in the main competition.

6.13 Devices must be fixed securely by use of the location pin. Any device or part of a device that 'breaks free' during a competition heat or final will not receive any points for that attempt. Remaining shots can be attempted if the device is adjudged safe to continue.

6.14 Each device must have a quick and simple method of attaching and detaching the line, 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 control volume dimensions.

6.15 Teams are advised to pay particular attention to line-management during a launch sequence. Line management devices can be reloaded, reused or replaced during a heat or final.

6.16 Line must be attached securely to the device at all times during a firing sequence and be contained within the operational envelope prior to firing.

6.17 The launcher must be constructed such that the ball can be loaded and then remain in position without the need for any form of restraint until the launch is triggered – this is the neutral position.

6.18 The neutral position cannot be used as a means of pre-setting the trajectory for any of the targets. There must be definite movement of the device from the neutral position for every target fired at.

6.19 The ball must be loaded manually without energising the firing mechanism or device in any manner.

6.20 Devices must be fired remotely via a low voltage, wired, electrical switch at least 2m distance from the device.

6.21 The firing switch and its wiring is the only component that is excluded from the operational envelope.

6.22 The device cannot be operated wirelessly at any time, nor can it be controlled remotely, except for initiating the launch sequence.

6.23 The device must aim, energise and fire automatically – the firing process.

6.24 The device must be fully autonomous during the entire firing process after the firing switch has been pressed.

6.25 Loading and re-loading of the device must take place with the Device Controller standing behind the Safe Loading Line, which is the rear of the launch platform. This is to ensure that nobody is ahead of the firing line at any time.

6.26 When in the neutral position, a green light must be lit, which is clear for all to see, including spectators.

6.27 When the device is energised, a similar red light should be lit, which is clear for all to see, including spectators.
7. Competition Rules for the Line Launcher

7.1 All devices must be available for scrutineering prior to commencement of the competition.

7.2 Teams must supply their own safety glasses, which must always be worn by anyone working on the device. Teams that fail to provide suitable safety equipment will have their top heat score erased.

7.3 Safety glasses must be worn by the Device Controller just prior to arming and at all times during the heats/final where a device may fire.

7.4 No practice firing of any projectile is permitted, the device may, however, be tested for all other functionality.

7.5 A device that fires prematurely at any time during the competition will forfeit its next pending attempt.

7.6 Clear instruction on the running order for the heats and finals will be given at the event.

7.7 Organisers will announce the target ranges during the morning of the competition.

7.8 Teams will compete head to head in heats for a place in the final. The relative performance will be determined by teams accumulating points during a launch sequence.

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

7.10 Participating teams will have a minimum of 3 minutes before a heat or final to program and position their device on the firing line.

7.11 The time limit for the heats and final will be two minutes. Time will start from the end of the timekeeper’s starting countdown.

7.12 Teams will fire at the target from various distances during the heats. At the given range, teams will be required to hit each of three target grids at different vertical heights within the two-minute time limit.

7.13 Teams not ready within the allotted time before a heat or final will forfeit that attempt.

7.14 All teams must display an A4 sheet detailing the teams name and University and this must be clearly displayed as instructed during any run in which the team is taking part.

7.15 Each team must appoint a ‘Device Controller’ who will be the only person to attend to the device during a launch sequence.

7.16 No person is to be between the device and target once loaded.
7.17 During a launch sequence all other team members must be outside the test area. A judge will be allocated to each test area to ensure the correct procedure is followed.

7.18 At the start of a heat, teams will be given three squash balls with lines attached.

7.19 The first ball may be loaded during the three-minute preparation time. The device may be aligned horizontally during this period, but must not be aimed vertically, or energised, in any way.

7.20 Operators will raise their hand clearly to show readiness within the three-minute period, if all operators are ready to fire, a heat can commence.

7.21 Once ready, teams will be instructed to “Prepare to Fire” and Device Controllers will retire to the safe firing position, then on a count of 3, 2, 1, FIRE! each team will fire their device using the remote firing switch. The two-minute countdown will start.

7.22 If a device is started before the starters order it will forfeit that attempt.

7.23 Once the first ball has been fired, the device must be returned to its neutral position. This can be done automatically, or manually by the Device Controller.

7.24 No adjustments can be made mechanically or electronically during the time limit, except for re-aligning the device horizontally by means of the location pin and wing nut, so long as the launcher is de-energised and is in its neutral position.

7.25 The launching process can then be repeated for balls two and three to be fired at the targets at the other heights.

7.26 The third ball must have been launched within the time limit given. Any balls that are already in flight will still be scored.

7.27 Once all devices have fired all their shots (or been made safe if not fired) judges will record the scores and teams will be instructed to retrieve balls and line.

7.28 If a device fails to fire or remains energised in any way, the Device Controller must inform their judge and immediately operate the locking safety mechanism before making the device safe by operating the energy safety system. Any remaining shots can still be attempted within the time limit after the device has been de-energised and returned safely to the neutral position.

7.29 It is permissible to replenish the device’s energy source between heats, but not during a launch sequence. 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.

7.30 Any queries about the equipment during the competition must be raised with the head judge. Only the team leader is allowed to approach the official and the team must abide by any decision made.

7.31 Breach of any rule during competition will forfeit that heat or final.

7.32 Continued breaches or behaviour unbefitting of the spirit of the challenge will result in the team being disqualified from the competition.

7.33 A video camera will continuously film the activity in the competition lanes so that if there is a dispute it can easily be resolved.

7.34 If a device does not meet these requirements, and modification cannot be made within the allocated time period to allow it to comply, then it will be deemed withdrawn from the competition.

8. Scoring for the Line Launcher Competition

8.1 Note: every heat consists of firing three balls and is referred to as a launch sequence elsewhere in these regulations.

8.2 A maximum of 30 points is available for each of the three heats of the Line Launcher Competition.

8.3 A maximum of 30 points is available for the final of the Line Launcher Competition.

8.4 In the event of a tie in either the heats or final, a one-off decider will take place at a distance to be determined by the judges.

Regional Finals

8.5 The maximum score available in a heat is 30 points. The scores from every heat will be noted and each team will have their best score from all the heats recorded. The three teams with the highest points in the heats will go through to the final.

8.6 A maximum of 30 points is available in the final. Points from the heats will not be carried forward. The winner will be the team achieving the highest score in the final.

National Finals

8.7 A total of 90 points will be available in the heats. The top three teams in the heats returning the highest accumulated scores will progress to the final.
8.8 Scores from the heats will be carried forward to the final. 30 points will be available in the final, meaning a total of 120 points is possible for the line launcher competition.

8.9 Scores from the line launcher competition will be added to the points awarded for the poster, presentation and design excellence elements to determine the overall national champion.

9. Rules for the Poster Competition

9.1 For the National Final, please note – The Poster should be submitted to the IMechE electronically via email – designchallenge@imeche.org - no later than one week before the date of the final. This allows for judging prior to the competition to save time on the day.

9.2 Each team should display their poster on the board provided and display their device on the table below their poster.

9.3 Please read Section 3.2 of the document “IMechE 2nd Year Design Challenge General Specification 2020” for all other Poster Rules.

9.4 Please see Appendix B of the document “IMechE 2nd Year Design Challenge General Specification 2020” for the Poster judging criteria.

9.5 A maximum of 10 points is available for the Poster Competition.

10. Rules for the Presentation Competition

10.1 For the Regional Competition, the maximum length of the Presentation is five minutes plus, typically, two minutes for questions.

10.2 For the National Final, the maximum length of the Presentation is seven minutes plus, typically, three minutes for questions.

10.3 Please read Section 3.3 of the document “IMechE 2nd Year Design Challenge General Specification 2020” for all other Presentation rules.

10.4 Please see Appendix C of the document “IMechE 2nd Year Design Challenge General Specification 2020” for the Presentation judging criteria.

10.5 A maximum of 10 points is available for the Presentation Competition.

11. Rules for the Peer Review Competition

11.1 Each team should examine the device from all of the other teams without handling them.

11.2 Whilst the peer review is being carried out there must be at least one member of each team present to answer questions etc.
11.3 Please read Section 3.4 of the document “IMechE 2nd Year Design Challenge General Specification 2020” for all other Peer Review rules.

11.4 Please see Appendix D of the document “IMechE 2nd Year Design Challenge General Specification 2020” for the Peer Review voting slips.

12. Rules for the Design Excellence Competition

12.1 Each team should display their device on the table beneath their poster.
12.2 Whilst the design excellence judging is being carried out there must be at least one member of each team present to answer questions etc.
12.3 Please read Section 3.5 of the document “IMechE 2nd Year Design Challenge General Specification 2020” for all other Design Excellence rules.
12.5 A maximum of 10 points is available for the Design Excellence Competition.


13.1 On matters relating to test equipment and procedure, the authority will be the Chair of the IMechE Design Challenge organising committee, or his/her delegated representative(s).
13.2 The panel of judges for the competition consists of impartial IMechE and university representatives.
13.3 The decisions of the panel of judges will be final.
13.4 In addition to the rules for the Regional Competition and National Final outlined above, universities are responsible for internally ensuring that the spirit of the competition is adhered to during the design and make stages.
13.5 Appeals: If a team wishes to lodge a complaint, to query a procedure or rule infringement, they must do so through the Chair of the IMechE Design Challenge organising committee, or his/her delegated representative(s). Any complaint will be investigated immediately, by at least two judges, and a response will be issued within a reasonable time. This decision will be final and not subject to further appeal.

Note - Judges are allowed to vary the rules slightly, if it is deemed necessary, to maintain the smooth running of the competition.
## Appendix 1 – Equipment List and Suppliers

<table>
<thead>
<tr>
<th>Item</th>
<th>Supplier</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Launch table:</strong></td>
<td>Scholar Crush Bent Square Tables by Office Furniture Online</td>
<td>£42.00</td>
</tr>
<tr>
<td>760H - 14 – Adult 600 mm W x 600 mm D x 760 mm H</td>
<td><a href="https://www.officefurnitureonline.co.uk/education-furniture/classroom-desks/square-rectangular-classroom-tables/scholar-crush-bent-square-tables.html">https://www.officefurnitureonline.co.uk/education-furniture/classroom-desks/square-rectangular-classroom-tables/scholar-crush-bent-square-tables.html</a></td>
<td></td>
</tr>
<tr>
<td><strong>Target Board – Option A:</strong></td>
<td>Smooth Hardwood Plywood Board by B&amp;Q</td>
<td>£27.86</td>
</tr>
<tr>
<td>(L)2.44m (W)1.22m (T)12mm</td>
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<td></td>
</tr>
<tr>
<td><strong>Target Board – Option B:</strong></td>
<td>Smooth MDF Board</td>
<td>£19.78</td>
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<tr>
<td>(L)2.44m (W)1.22m (T)12mm</td>
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<tr>
<td><strong>Target Sides:</strong></td>
<td>Birch Plywood Sheets</td>
<td>£22.74</td>
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<tr>
<td>600 x 300 x 4mm</td>
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<td></td>
</tr>
<tr>
<td><strong>Target Grids:</strong></td>
<td>Birch Plywood Sheets</td>
<td>£28.80</td>
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<td></td>
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<tr>
<td><strong>Ball:</strong></td>
<td>Dunlop Competition Squash Ball 12 Pack Yellow by Dunlop</td>
<td>£25.00</td>
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<td><a href="https://www.amazon.co.uk/DUNLOP-Competition-Squash-Balls-Single/dp/B0002QVMHM/ref=sr_1_4?keywords=dunlop+competition+squash&amp;qid=1564574958&amp;s=gateway&amp;sr=8-4">https://www.amazon.co.uk/DUNLOP-Competition-Squash-Balls-Single/dp/B0002QVMHM/ref=sr_1_4?keywords=dunlop+competition+squash&amp;qid=1564574958&amp;s=gateway&amp;sr=8-4</a></td>
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<tr>
<td><strong>Line:</strong></td>
<td>Times Spectra Extreme Braided Fishing Line Yellow</td>
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<tr>
<td><strong>Launch Pin:</strong></td>
<td>Bolt – Screwfix 11372 Easyfix BZP Steel Set Screws M10 x 50mm</td>
<td>£6.89</td>
</tr>
<tr>
<td>Washer – Screwfix 14327 Easyfix Large Flat Washers M10 x 2.5mm</td>
<td><a href="http://www.screwfix.com">www.screwfix.com</a></td>
<td>50 Pack</td>
</tr>
<tr>
<td>Wing nut – Screwfix 5195T Easyfix Zinc-Plated Steel Wing Nuts M10</td>
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<td>10 Pack</td>
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List of Amendments:

<table>
<thead>
<tr>
<th>Version</th>
<th>Page</th>
<th>Details</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>8</td>
<td>Full version released – multiple edits from draft version.</td>
<td>10-01-2020</td>
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<tr>
<td></td>
<td>13</td>
<td>Lower target aperture size now 90mm (was 100mm).</td>
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<td>Sponsor Awards added.</td>
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