

DESIGN CHALLENGE 1st & 2nd YEAR GENERAL SPECIFICATION 2023

IMechE DESIGN CHALLENGE

GUIDANCE FOR ALL PROJECTS



General Specification for the 2023 1st and 2nd Year Undergraduate Design Challenge

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Note: this specification must be read in conjunction with the respective document
“IMechE 1st (or 2nd) Year Design Challenge - Project Specification”
available on the [IMechE Design Challenge website](#).

Please check the IMechE Design Challenge website for updates.

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Please report any errors to Emma.Pateman@imeche.org so that corrections can be made.

List of Major Changes Since 2022

- The budget for 1st year teams has been increased to £50.

1. Introduction and Purpose of the Design Challenge

The purpose of the Design Challenge Competition is to simulate the requirements of a professional engineer so that students are exposed to the real world of engineering where they have to think for themselves and apply a systematic approach to solve an engineering requirement.

Working in teams, students have to design, build and test a self-contained device from a precise Project Specification.

The annual event takes place in three stages. Universities run internal qualifiers to select up to two teams to progress to their respective Regional Finals. The winning university from each region progresses to the National Final.

- 1.1 The competition is open to teams of two to six engineering degree students at the appropriate level.
- 1.2 There are five competition elements to the Design Challenge at the Regional Competition and National Final:

The Challenge

Design, build and test a device to compete with other teams.

Design Competition

Create a virtual prototype of your device along with a Bill of Materials.

Poster Competition

Produce an A3 (portrait) poster to publicise the teams' work. The poster is a demonstration of the team's ability to sell their design solution pictorially.

Presentation Competition

Give a short presentation explaining the design and development of their device, to demonstrate their verbal & presentational skills, and to answer questions from the judges.

Peer Review (Regional Competition Only)

Submit a peer review where all students have the chance to vote for the best engineered solution to the requirement.

Design Excellence (National Competition Only)

Present their designs to the judges to determine the best Engineering design using sound principles with an acceptable appearance.

The above covers the general requirements of a professional engineer.

1.3 The format of the Regional Competition and National Final is as follows:

<u>Regional Competition</u>	<u>National Final</u>
The Challenge	The Challenge
Design	Design
Poster	Poster
Presentation	Presentation
Peer Review	Design Excellence

1.4 Points will be awarded for all sections of the competition.

1.5 All the points scored for each section of the competition will be totalled to determine an outright champion.

The Challenge	60
Design	10
Poster	10
Presentation	10
Peer Review/Design Excellence	10
Total	100

1.6 Teams must compete in all sections of the competition to be crowned champions.

1.7 Prizes will also be awarded to the winners of each of the competition elements.

1.8 In the event of a tie of overall points, the team with the highest points in The Challenge will be the champions.

The regional competitions are normally held in March or April, but this is not prescriptive because it can be at any time to suit the universities in the region during the academic year.

The National Final of the Design Challenge Competition is held in October of each year at IMechE HQ.

2. Prizes and Certificates

In the Regional Competitions, each winning University will receive their Regional Design Challenge Trophy to keep until the next Regional Competition, and a certificate. All members of the winning team will receive a certificate.

In the National Final, the winning University will receive the prestigious Design Challenge Trophy to keep 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 Design Competition
- 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.

3. Sponsor Awards

In addition to the IMechE prizes, the Sponsor Awards will be given by the competition sponsors. These awards can be for specific aspects of the challenge, for teams and individuals. They may also include opportunities for industrial visits or placements with the sponsor. Please check for full details on the IMechE Design Challenge website for up-to-date information.

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.

4. Rules for The Challenge

GENERAL

- 4.1 Devices should be manufactured using available facilities and materials, using processes that students can do themselves with minimal guidance.
- 4.2 Off-the-shelf components may also be purchased, such as motors, batteries, gears, bearings, fasteners and so on.
- 4.3 All components, whether manufactured or bought, must comply with the Design Challenge regulations.

- 4.4 All devices must be 'signed off' by the academic staff member of the individual university, to say that their team's device meets all of the scrutineering rules.
- 4.5 On the day of the competition, and after successfully completing the scrutineering process, teams will be given a sticker to be attached to the device as proof of scrutineering.
- 4.6 Any team which tries to enter a heat without this sticker will not be allowed to compete.

COST

- 4.7 The Total Cost of the device (*including VAT at 20%*) is to be as follows:
 - under £50 for the 1st year competition.
 - under £100 for the 2nd year competition.
- 4.8 The Total Cost, shown above, must include all parts and materials priced at, or over, £0.20 used to make the device. Parts with a value of less than £0.20 do not need to be included in the total cost.
- 4.9 A full parts list with all itemised costs, including those under £0.20, must be produced according to the Design Competition rules (see Bill of Materials). This is known as the BOM cost and is not the same as the Total Cost in 4.8.
- 4.10 All purchased materials and parts must be listed with the as-new normal retail purchase price from established suppliers (*including VAT* but excluding carriage).
- 4.11 Invoices, receipts, or proof-of-purchase must be available on the day of the competition for all materials and bought components, for inspection by the judges during the static competition and scrutineering.
- 4.12 Components or materials 'in-kind', or provided free by the university, or from any other source, must be included in the parts list, and costed as appropriate at its as-new price.
- 4.13 A component or material is considered to be 'in-kind' if it is not commercially available for purchase by other teams or cannot be supplied at the same price.
- 4.14 In addition, the total cost must also include any replacement, or substitute parts, used during the heats and final of The Challenge. This must include spare sets of batteries, for example, changed during the heats, and they must be counted towards the total cost of the device. This rule is to prevent teams using expensive batteries and replacing them as new for each heat, without including them in the cost. Put simply, any parts used on the device on the day of competition must be included in the total cost.
- 4.15 Teams may be expected to justify the purchase price of any item of the device.
- 4.16 The cost of manufactured parts must be calculated based on the raw materials used.

- 4.17 Standard sheet/bar materials should be charged as a proportion used per device, within reason. For example, if the purchase of a 6m length of steel bar cost £18 and 200mm were used, the cost recorded would be £0.60 ($£18 \times 0.2 / 6.0$). Purchase of 600m of bar would be deemed unreasonable.
- 4.18 The cost of generic tools (drills, saws, files, etc.) need not be included. Likewise, the cost of a battery charger, or air compressor, etc., can be excluded, as they are considered general-use workshop items.

ADDITIVE MANUFACTURING

- 4.19 Rapid prototyping or additive manufacture is permitted. Teams should use this method for making individual parts and not for producing the whole assembly.
- 4.20 Parts produced this way will be costed the same as other raw materials. For instance, a 2.3kg reel of filament costing £57.00 will be costed at 2.48p per gram.

SAFETY

- 4.21 Teams are encouraged to think very carefully about safety and must provide a signed risk assessment to accompany their device at the competition.
- 4.22 All devices and their risk assessment must be 'signed off' by the academic staff members of the individual universities to say that their students' devices are deemed safe to operate in a lecture theatre or sports hall environment at the competition.
- 4.23 Teams must supply their own safety glasses as appropriate. Teams that fail to provide suitable safety equipment will have their top heat score erased.
- 4.24 Lithium batteries are not permitted due to the risk of fire and explosion, but other types of safe, rechargeable batteries may be used.
- 4.25 Pressurised air/gas systems are allowed but they must be declared safe and reasonable by the participating University and not subject to the "Pressure Equipment Directive" (directive 97/23/EC) namely volume <1 L, pressure volume <50 bar L.
- 4.26 No explosive charges or combustion can be used.
- 4.27 Consideration must be given to guarding if there is risk of entanglement or entrapment.

5. Project Specification for The Challenge

The adopted project for The Challenge will change every year to prevent ongoing development and convergence in performance. In each case this General Specification will apply for the competition and the rules of engagement.

Please see the respective document "IMechE 1st (or 2nd) Year Design Challenge - Project Specification" available on the IMechE Design Challenge website. This includes all the technical regulations and rules needed for building a device to complete The Challenge.

6. Rules for the Design Competition

In the real world, virtual prototyping and simulation can significantly reduce development times and costs. Product development requires a judgement to be made between this and the level of physical prototyping and testing that is required. A balance has to be found to ensure that a high-quality, durable, reliable product is delivered to budget and on time.

The Design Competition is made up of three elements: a virtual prototype, a bill of materials and a design review.

To demonstrate their ability to create a concept, teams are required to submit a virtual prototype of their design. The ultimate aim is to produce a 100% realistic model of the design, which is accurate in every detail, so that it represents exactly what will be built. The Computer Aided Design (CAD) will be submitted to the judging panel ahead of the competition date.

- 6.1 Teams are required to submit a fully-detailed virtual design of a device that will complete the IMechE Design Challenge.
- 6.2 The virtual prototype must match the device that competes in the Main Competition and will be judged for similarity on the day.
- 6.3 In terms of physical similarity, assemblies must include the finer detail, such as fasteners.
- 6.4 Wiring is one of the most difficult items to model in 3D. Teams are encouraged to attempt to model wires to gain experience, but this will not form part of the scoring.
- 6.5 The virtual prototype is to be submitted in STEP AP203 format via the IMechE Design Challenge website. Details will be circulated to teams at the time.
- 6.6 Teams are strongly advised to check the integrity of their STEP file before submitting it, to check for any translation errors, and to ensure that it includes the complete assembly of the device with no parts missing.
- 6.7 Submitted models must be an assembly of individual solid bodies, and not one single entity.

- 6.8 Individual parts within the assembly must be solids with mass and volume, and not surface models, which are just a shell.

Teams must also submit a Bill of Materials (BOM) to accompany their design. This is a detailed parts list which also includes information such as materials, cost and suppliers. Please see the supplementary document "IMechE Design Challenge – BOM Template". Teams must use the IMechE Excel spreadsheet template which is provided on the Design Challenge website.

- 6.9 Teams must submit a Bill of Materials (BOM) to accompany their virtual prototype. The BOM must include the following information for each item, in the BOM template that will be provided:

Part Name
 Part Number
 Quantity
 Material
 Density – in kg/m³
 Mass – in kg
 Cost – in £0.00
 Supplier
 Hyperlink to supplier's website

- 6.10 Every individual item must be included in the cost entry in the BOM. This includes items costing less than 20p.
- 6.11 The BOM template will have two totals, one for items costing more than 20p (the Total Cost, rule 5.7), and one for items less than 20p (the BOM Cost).
- 6.12 Material and density properties are included so that judges can verify the accuracy of the model by applying material properties to individual components to check the calculated masses provided in the BOM.

At the Regional and National Finals, every team will take part in a design review conducted by the IMechE judging panel. During the review the judges will discuss aspects of the design that they may have noted during preliminary scoring of the virtual designs.

- 6.13 CAD models will be projected onto the screen during the review by the judges.
- 6.14 The length of the design review will last for 5 minutes per team, but this may vary depending on the number of teams taking part.

7. Scoring for the Design Competition.

The virtual prototype and bill of materials will be assessed in accordance with the scheme below:

Judging Criteria		Weight (%)
Virtual Prototype	Overall quality of the virtual prototype model	20
	Inclusion of the finer details such as fasteners and standard parts	10
	Compliance with Design Challenge rules	5
Bill of Materials	Overall accuracy of the BOM – including all items in the assembly	10
	Cost analysis for the entire device, including items less than 20p	10
	Accuracy of costs for manufactured parts and bought components, including spares	5
Review at Competition	Mass of the actual device compared to the calculated BOM mass	5
	Cost analysis includes all prices inc. VAT	5
	Accuracy of the virtual model compared to the real device on display, including fasteners and standard parts	10
	Design review	20
Total		100
Score = Total / 10		10
Rounded up to a whole number		

8. Rules for the Poster Competition

- 8.1 The poster should be A3 size in portrait format. It should clearly display the logos of the team's university and of the IMechE.
- 8.2 The poster should concisely describe the device, how it operates and the engineering principles it is based on. It should include, but is not limited to:
 - a. sketch, 3D visualisation or 2D technical drawings representing the device,
 - b. text to explain important features shown in the drawings,
 - c. details of how and why the device works, using diagrams if necessary, and
 - d. brief details of the team members.
- 8.3 Detailed costing of the device is not required on the poster, but a summary of the Total Cost should be included.
- 8.4 Each team should display their poster on the board provided and display their device on the table with their poster.
- 8.5 Posters must also be submitted electronically no later than 2 weeks ahead of the date of the Regional Competition or National Final. Details will be circulated to teams at the time.
- 8.6 The submitted poster is the version that will be judged.

9. Scoring for the Poster Competition

The poster will be assessed in accordance with the scheme below:

Judging Criteria		Weight (%)
Visual Impact	Compliance with rules – size (A3) and orientation (portrait)	10
	Obvious information on the university represented (logos) and the team members' names	10
	Good use of colour, layout, text and space to convey meaning	10
Technical Content	Clear but brief textual description of the competing device	10
	Clear diagram(s) – sketch, rendering or CAD model – of the device	15
	Evidence of the engineering science underpinning the device	15
	Facts and figures for the performance characteristics of the device	15
	Summary costing of major components of the device	15
Total		100
Score = Total / 10		10
Rounded up to a whole number		10

10. Rules for the Presentation Competition

10.1 The maximum length of the presentation is five minutes.

10.2 The presentation should be delivered by all the team members.

10.3 The presentation should include, but is not limited to;

- a. the principal features of the final design,
- b. the engineering science that underpins the device,
- c. the steps the team followed to arrive at the design, and
- d. the total cost of the final design and if/how costs influenced the final design

10.4 The presentation must be recorded and submitted electronically no later than 2 weeks ahead of the date of the Regional Competition or National Final. Details will be circulated to teams at the time.

10.5 The submitted presentation is the version that will be judged.

10.6 At the Regional and National Finals the top three teams will be announced at the event and their presentations will be shown live.

10.7 The top three teams will answer questions on their design for up to three minutes.

11. Scoring for the Presentation Competition

The presentation will be assessed in accordance with the scheme below:

Judging Criteria		Weight (%)
Presentation Style	Audience Engagement	15
	Quality of spoken presentation (well structured, fluent, clear etc.)	15
	Quality of visual aids (clear and easily readable, do not duplicate spoken presentation etc.)	15
Technical Content	Principal features of the final design	15
	Steps followed to reach the final design, including costing of the device	15
	Engineering science that underpins the final design	15
Q & A	Answer to judges' questions (top three teams only)	10
Total		100
Score = Total / 10		10
Rounded up to a whole number		10

12. Rules for the Peer Review Competition

12.1 The Peer Review Competition takes place in the Regional Final.

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

12.3 During the examination teams should be looking for the following;

- a. design principles used,
- b. the simplicity of the design,
- c. the robustness of the design,
- d. the manufacturing excellence, and
- e. the general appearance.

12.4 Teams then vote for their top three using the voting slips provided by the IMechE on the day.

12.5 Whilst the peer review is being carried out there must be at least one member of each team present to answer questions etc.

13. Rules for the Design Excellence Competition

13.1 The Design Excellence Competition takes place in the National Final.

13.2 The device will be judged under the same criteria as the Peer Review.

13.3 Whilst the design excellence judging is being carried out there must be at least one member of each team present to answer questions etc.

14. Scoring for the Design Excellence Competition

The design excellence will be assessed in accordance with the scheme below:

Judging Criteria	Weight (%)
Design principles applied	20
Simplicity of design	20
Robustness	20
Manufacturing excellence	20
Appearance	20
Total	100
Score = Total / 10 Rounded up to a whole number	10

15. Enforcement of the Rules

- 15.1 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).
- 15.2 The panel of judges for the competition consists of impartial IMechE and university representatives.
- 15.3 The decisions of the panel of judges will be final.
- 15.4 In addition to the IMechE outlined above, universities are responsible for internally ensuring that the spirit of the competition is adhered to during the design and make stages.
- 15.5 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.
- 15.6 Appeals must be raised by a nominated team leader. The remaining team members, team supervisors, or university staff members, can only contribute to an appeal if requested to do so by the Chair of the IMechE Design Challenge organising committee, or his/her delegated representative(s).

Note - Judges are allowed to vary the rules slightly, if it is deemed necessary, to maintain the smooth running of the competition.