EXO GAMES CHALLENGE SPECIFICATIONS

GUIDANCE FOR ALL PROJECTS

Specification for the 2023
EXO GAMES

Contents

List of Amendments:

Version	Page	Details	Date
1.0	-	Full Release (no changes from DRAFT V0.2)	28-10-2020
2.0		Made suggested edits to several areas, majority in section 4	10 June 2022
4.5		All sections modified or edited	23 January 2023
4.7		Accepted all previous changes and removed references to a separate project specification	27 Jan
4.8		Updated cup stacking to include fumbles	17 April 2023
4.81		Updated cup stacking to sustainable paper cups	10 May 2023
4.82		Updated TUG test to include chair specs and pictures	15 May 2023
5.0		Major update Sections 2, 6, and 7. Combined the judging of the Physical Design with the Poster Competition. Combined the judging of the Virtual Design with the Presentation Competition	18 May 2023

1. Introduction and Purpose of the Design Challenge

The purpose of the Exo Games competition is to simulate the requirements of an engineer or scientist so that students are exposed to the real-world application of STEM where they have to think for themselves and apply a systematic approach to solve an engineering requirement.

1.1 The competition is open to university teams of students at the appropriate level.

1.2 Each team can use just one exo technology device at the competition, but all students who work on the challenge will benefit from the learning experience of applying their technical knowledge.

1.3 Working in teams, students must design, build, and test a self-contained exo technology device. Teams must produce a design solution, make it, test it with the predefined ASTM standards, and compete.

1.4 Definitions:

a. Exoskeletons are wearable devices that augment, enable, assist, and/or enhance physical activity through mechanical interaction with the body. (ASTM F3323)
b. Exo technology includes the exoskeleton and supporting hardware, software, and other systems necessary for their function.

1.5 There are four competition elements to the Design Challenge:

<u>Main Competition</u>
Design, build and test an exo technology device to compete with other teams.

<u>Design Competition</u>
Present a virtual prototype and their physical device to the industrial judges to determine the best solution using sound principles with an acceptable appearance.

<u>Poster Competition</u>
Produce a poster to publicize the teams' work. The poster is a demonstration of the team's ability to sell their design solution pictorially.

<u>Presentation Competition</u>
Give a short presentation explaining the design and development of their device to demonstrate their verbal & presentational skills.

The format of the Final is as follows:

- Main Competition
- Poster and Design (physical) Competition
- Presentation and Design (virtual) Competition

Time	Day 1	Day 2	Day 3
Morning	Poster and Design (physical) Competition	Main Competition (TUG, Bomb Squad Walk, Warehouse Repalletizing, & Cup Stacking)	Invited Presentations
Lunch			
Afternoon	Main Competition (TUG, Bomb Squad Walk, Warehouse Repalletizing, & Cup Stacking)	Presentation and Design (virtual) Competition	Award Ceremony

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

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

1.8 Points will be awarded for the heats and final of the Main Competition.

1.9 In the Main Competition, Design Competition, Poster, and Presentation will be treated separately. Performance in one element will not affect any other section.

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

Poster	10
Presentation	10
Design (Virtual + Physical) Competition	20
Main Competition	60
Total	100

1.11 In the event of a tie of overall points after the competition final, the team with the highest points in the Main Competition will be the champions.

1.12 Where there is a large number of teams, it is permissible for each university to enter one team in the Poster Competition and one team in the Presentation Competition. This should only be considered due to time restraints. Under these circumstances, if a university enters only one team, they must compete in both the Poster and the Presentation Competitions.

1.13 All submissions must be considered non-proprietary information. All teams will sign a video/audio release form to participate.

2. Prizes and Certificates

A cash prize will be awarded to first- and second-place winners, $5,000 and $1,000 respectively. ASTM reserves the right to award no prizes based on the determination of the judges.

The overall winning team will receive the prestigious Exo Games Trophy 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:

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.

All members of the other participating teams will receive certificates. Certificates will only be awarded to participating team members.

3. Sponsor Awards

In addition to the ASTM prizes, Sponsor Awards may 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 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. Exoskeleton Challenge Tests (Main Competition)

Four exoskeleton tests have been determined for the Main Competition. Each of the four challenge tests represent a real-life application so that the students can see a reason for developing such a project. All tests will be measured by, at a minimum, degree of completion and time to complete. The following ASTM standards may be used by Teams to help guide design decisions and were utilized to develop this general specification.

<u>ASTM Standards:</u>
F3323 Standard Terminology for Exoskeletons and Exosuits

F3358 Standard Practice for Labeling and Information for Exoskeletons

F3392 Standard Practice for Exoskeleton Wearing, Care, and Maintenance Instructions

F3427 Standard Practice for Documenting Environmental Conditions for Utilization with Exoskeleton Test Methods

F3443 Standard Practice for Load Handling When Using an Exoskeleton

F3444/F3444M Standard Practice for Training Exoskeleton Users

F3474 Standard Practice for Establishing Exoskeleton Functional Ergonomic Parameters and Test Metrics

F3517 Practice for Movement Tests When Using an Exoskeleton

F3518 Guide for Quantitative Measures for Establishing Exoskeleton Functional Ergonomic Parameters and Test Metrics

F3519 Guide for Establishing a Reporting Structure for Exoskeleton Analysis

F3527 Guide for Assessing Risks Related to Implementation of Exoskeletons in Task-Specific Environments

F3528 Test Method for Exoskeleton Use: Gait

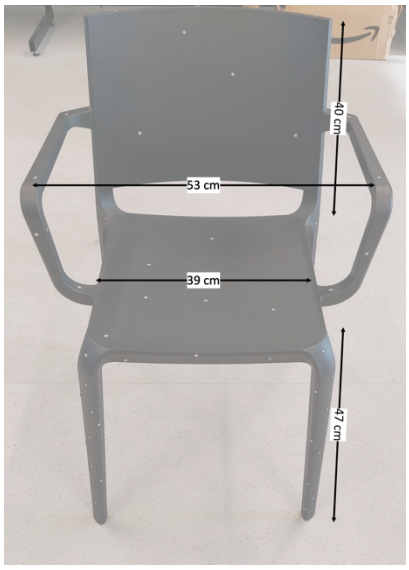
F3540 Guide for Hazards for Consideration When Designing Exoskeletons

F3523 Standard Test Method for Exoskeleton Use: Confined Space: Horizontal Movement

F3578 Standard Test Method for Evaluating Exoskeleton Fall Risk due to Stumbling

<u>TEST 1</u>
Timed Up and Go (TUG) test (ASTM F3528)

- A chair with armrests* is placed in the test area. The chair must not move (that is, chair includes non-skid feet) when the user sits on the chair or stands from the chair.
- At 3 m from the front of the chair, a tape line or visible mark is placed on the floor.
- A practice test should be completed before the timed test.
- The user starts in a seated position.
- The test supervisor instructs the user to stand up, walk 3 m, turn around, walk back to the chair, and sit down when the test supervisor says “start.” At which time the test technician begins timing the test with a stopwatch.
- The test supervisor stops the stopwatch when the user is seated.



**The chair’s dimensions are as follows: from foot to seat 470 mm, seat to upper back 400 mm, seat width 390 mm, and inner arm to arm 530 mm.*


Side

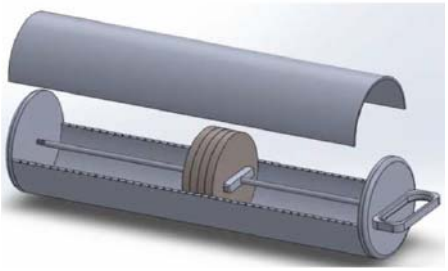

Back


Front

TEST 2

Bomb Squad Walk

- The user must put on a 25lbs weighted vest and pick up two 15lbs weights (ie, load cylinder artifact), one in each hand.
- The user must walk 300m and place the weights on the ground
- The user must kneel, squat, or sit down to complete a manual dexterity task
- Once the task is complete, the user must retrieve the two weights and walk back 300m to the start/finish line


Load Cylinder Artifact from ASTM F3443.

TEST 3

Warehouse Re-palletizing

- The task is to take a pallet full of boxes of varying size and weight and move them to a table and then put them back on the pallet.
- The boxes will vary with the largest and heaviest loads being a 24-case of glass beer bottles that measures 46-cm long × 31-cm wide × 23-cm high (18-in. long × 12-in. wide × 9-in. high), with cut-out handles. It weighs 18 kg (40 lbs), and the weight is equally distributed. (ASTM F3443)
- The user grips the box and carries the box at torso level with the case touching their stomach or chest, or both. No instructions are given on how specifically to lift up or place down the box. User may carry more than one box at a time as long as they can do so safely.

- The user starts by standing 31 cm (1 ft) in front of a 102-cm wide × 122-cm deep × 17-cm tall (40-in. wide × 48-in. deep × 6.5-in. tall) pallet with the load on top. The user begins in a comfortable standing posture, facing the load with feet side-by-side and approximately shoulder width apart.
- The user lifts the box, turns 180°, then carries it 305 cm (10 ft) in a straight line to a 76-cm high (30-in. high) table, and places the box on the table. There are no other obstacles in the environment.
- The box is to be placed so that it is fully on the table (not overhanging edge), near the front edge. On the table the load should be oriented so that handles are located on left and right sides relative to the user facing the load.
- The user then reverses this procedure once all the boxes are on the table and replaces the boxes onto the pallet.

TEST 4

Speed and Dexterity (Cup Stacking)

- The user starts with 8 oz paper coffee cups* nested in a 3 – 6 – 3 stacks.
- Working from left to right, stack 3, then 6, then 3, go back to the beginning and down stack.

Fumble – The term used when cups fall during the process of up stacking or down stacking

Fumbles - If a fumble should occur during the “up stacking phase,” it must be fixed immediately with the exception of a down stacked column of cups that fall over on its side, in which case it need not be fixed until it is up stacked in sequence. To “fix” a fumble properly in the up stacking phase without incurring an infraction, the Stacker must fix the fallen cup(s) BEFORE up stacking the next stack. The “down stacking phase” begins once the Stacker starts down stacking the first stack in the sequence. Once in the down stacking phase, fumbled cups NEED NOT be rebuilt into pyramids but simply down stacked into nested columns.
(Adapted from Version 8.1 of The World Sport Stacking Association Rule Book)

* *The paper cups are double wall kraft brown are certified compostable according to EN13432 and the ASTM D6400.*

5. Competition Rules for All Projects

GENERAL

5.1 The Exoskeleton should be manufactured using available facilities and materials, using processes that students can themselves work with under minimal guidance.

5.2 The exoskeleton must have as a basis for attaching to the body a certified fall harness. Other body attachments may be made as needed. No modifications to the fall harness are allowed that would render it unsafe.

5.3 Off-the-shelf components may also be purchased, such as motors, batteries, gears, bearings, fasteners and so on.

5.4 All components, whether manufactured or bought, must comply with the ASTM Design regulations.

5.5 All devices must be 'signed off' by the academic staff member of the individual university, to say that their teams' device meets all the scrutineering rules before the Competition.

5.6 On the day of the competition, and after successfully completing the scrutineering process, teams will be given a sticker. This must be attached to the device as proof of scrutineering.

5.7 Any team which tries to enter a heat without this sticker will not be allowed to compete.

COST

5.8 The total cost of the device is to be as follows:

under $2000.

5.9 The total cost 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.

5.10 A full parts list with all itemised costs, including those under $0.20, must be produced according to the Exoskeleton Design rules.

5.11 All purchased materials and parts must be listed with the as-new normal retail purchase price from established suppliers.

5.12 Invoices, receipts, or proof-of-purchase must be provided ahead of the competition for all materials and bought components for inspection by the judges during the static competition and scrutineering.

5.13 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.

5.14 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.

5.15 Teams may be expected to justify the purchase price of any item of the device.

5.16 The cost of manufactured parts must be calculated based on the raw materials used.

5.17 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 x 0.2 / 6.0). Purchase of 600m of bar would be deemed unreasonable.

5.18 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

5.19 Additive manufacturing is permitted.

5.20 Parts produced this way will be costed the same as other raw materials. For instance, a 2.3kg reel of filament cost $57.00.

DESIGN SAFETY

5.21 Teams are encouraged to think very carefully about safety. All devices 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. Designs should have a factor of safety of 3 at a minimum. Designs with lower factors of safety should be documented with a justification.

5.22 Teams must supply their own safety glasses as appropriate. Teams that fail to provide suitable safety equipment will have their top heat score erased.

5.23 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<5 bar L.

5.24 No explosive charges or combustion can be used.

5.25 Propulsion systems may not include explosives or combustion. Devices must be regarded as safe and reasonable and conform with this 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.

5.26 The exoskeleton must be fully controllable by the wearer.

5.27 The exoskeleton must be able to be removed by the wearer in <1 minute.

5.28 All exoskeletons with power must have a kill mechanism to render it safe in case of emergency. The kill mechanism must be labelled and inherently visible to any person responding to an emergency.

5.29 Wireless communication with the exoskeleton, sensors, and/or other wearable devices is permissible as long as this is not for someone remotely controlling and overriding the wearer

5.30 Wireless power beaming to the exoskeleton is permissible if the team can demonstrate that the level of electromagnetic radiation would not harm the wearer or any other personnel in the area.

5.31 No invasive attachments or devices are allowed such as subdermal implants, piercings, or permanent electrical circuit tattoos. Temporary electrical circuit tattoos, wearable devices, and sensors are allowed on the skin.

6. Rules and Scoring for the Poster and Design (physical) Competition

6.1 The poster should be 594 x 841 mm /24” x 36” inch size in portrait format. It should clearly display the logos of the team’s university and of the ASTM Exo Technology Centre of Excellence.

6.2 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 visualization or 2D technical drawings representing the device,
b. text to explain important features shown in the drawings,
c. details of how the exo works, using diagrams if necessary, and
d. brief details of the team members.

6.3 Detailed cost of the device is not required on the poster, but a summary should be included.

6.4 The poster is a demonstration of the team’s ability to sell their design solution.

6.5 The poster will be assessed by the appointed judges, in accordance with the marking scheme below:

POSTER

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

6.6 Each team should display their device on the table beneath their poster.

6.7 The design will be assessed by the appointed judges, in accordance with the marking scheme below:

DESIGN (PHYSICAL)

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 whole number**	**10**

7. Rules and Scoring for the Presentation and Design (virtual) Competition

7.1 Presentations should be submitted (on a memory stick) on arrival at the Competition.

7.2 The maximum length of the presentation is fifteen minutes plus, typically, 5-10 minutes for questions. The presentation can be delivered by any number of team members, from one person to all members of the team. Computer and projector facilities with common software will be available.

7.3 The presentation should include, but is not limited to:

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

7.4 The team will be required to answer questions on their design.

7.5 The presentation is a demonstration of the team's ability to verbally present their design solution.

7.6 The presentation will be assessed by the appointed judges, in accordance with the marking scheme below:

PRESENTATION

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 cost of the device	15
	Engineering science that underpins the final design	15
	Answer to judges' questions	10
Total		**100**
Score = Total / 10 **Rounded up to whole number**		**10**

7.7 The virtual prototype and bill of materials will be assessed and judged by the appointed judges, in accordance with the marking scheme below:

DESIGN (VIRTUAL)

Judging Criteria		**Weight (%)**
Virtual Prototype	Accuracy of the virtual model down to the finer details, or similarity compared to the real parts on display	20
	Accuracy of the masses and inertias of the virtual model	10
	Compliance with Exo Games rules	10
Bill of Materials	Overall accuracy of the BoM – including all items in the assembly	20
	Cost analysis for the entire device, including items less than $0.20	20
	Accuracy of costs for manufactured parts	10
	Accuracy of costs for bought components, including spares	10
Total		**100**
Score = Total / 10 **Rounded up to whole number**		**10**

8. Enforcement of the Rules

8.1 On matters relating to test equipment and procedure, the authority will be the Chair of the ASTM Exo Games Challenge, or his/her delegated representative(s).

8.2 The panel of judges for the competition consists of impartial ASTM and university representatives.

8.3 The decisions of the panel of judges will be final.

8.4 In addition to the rules for the Competition outlined above, universities are responsible for internally ensuring that the spirit of the competition is adhered to during the design and make stages.

8.5 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 ASTM Exo Games Challenge organizing 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.