Mapper’s Interstellus

ROUND 1 : LONDON EYE

Delegation Cap(3 delegates)

1. **Introduction & Summary**

This module immerses delegates in the core principles of mechanical and electromechanical engineering, focusing on how theoretical physics and practical design intersect in real-world systems. Delegates will explore forces, motion, energy transfer, structural stability, and system optimization through progressively challenging hands-on rounds.
Across the three rounds, delegates journey from conceptual understanding, to mechanical construction, and finally to system optimization and justification. Each round builds on the previous one, ensuring that by the end of the module, delegates can confidently design, analyze, and defend an engineered system under realistic constraints.

2. **Rounds Description:**

a. Round Name: London Eye
b. Overview & Significance:

- In the engaging first round, “London Eye,” delegates will take on the challenge of constructing a DC-motor-powered Ferris wheel capable of carrying loaded cabins without tipping or interrupting rotation. This activity emphasizes the application of core mechanical principles, including torque, rotational motion, load distribution, and centre of gravity, to achieve smooth and continuous operation within defined constraints. Teams will follow a structured process of planning, construction, testing, and refinement to ensure their Ferris wheel maintains stability throughout its rotation. Delegates must carefully consider cabin placement, weight balance, frame geometry, and axle alignment, while ensuring the motor-driven system operates at a consistent speed. Structural integrity and effective integration of mechanical and electrical components will be important throughout the round. Teams will be given a limited time window to construct their Ferris wheel using basic structural materials and simple electrical components, such as a motor-driven rotation system and support elements, provided during the round. Once assembled, the system will be tested with weighted cabins to evaluate overall performance. During evaluation, judges will focus on stability under load, smooth and continuous rotation, and overall quality of construction, assessing how well the mechanical system performs under realistic operating conditions.“London Eye” celebrates precision engineering, teamwork, and practical problem-solving. It provides delegates with an opportunity to demonstrate mechanical ingenuity while engaging with the challenges of designing rotating systems under realistic engineering conditions.

Module Heads are looking for **functionality first**, followed by efficiency, neatness, and justified design decisions.

c. **Provided Resources**

- 9V DC Battery
- DC Motor (6–12V compatible)
- Wooden sticks (structural support)
- Copper wire

- **ii. Delegate Requirements**
- No personal tools or electronics are required
- Delegates must rely solely on provided materials
- Teams must consist of **2 delegates only**

d. Elimination Percentage

- **40-50% of teams** will be eliminated after Round 1 based on overall performance and mechanical reliability.

3. **The Preparation & Study Resource Hub**
This is the final section of the document. For each round, you must provide a dedicated resource table, here is an example:

Category	Possible Resources
Topics to Study:	Rotational motion, torque, center of mass, friction, load distribution
Skills to Master:	Structural stability, motor integration, balance optimization, teamwork
Essential Reading:	Concepts of Rotational Motion Working Principle of DC Motor: Explained for Beginners - Regent Electronics What is the relationship between the center of gravity and the load distribution?
Inspirational Gallery:	How Does A FERRIS WHEEL Work The Physics of Ferris Wheels

Round 2 - Clawquest Showdown
Delegation Cap(3 delegates)

- **Introduction and Summary**

Round 2 is themed as the Arcade Trial, where engineering meets performance under pressure. Delegates step into the role of machine designers tasked with bringing a classic arcade claw to life - powered not by electricity, but by hydraulics. Using only syringes, tubing, and structural materials, teams must construct a claw machine that moves with precision and responds smoothly to human control, embodying the challenge of mastering fluid-driven motion.

Once built, the arena transforms into an arcade floor. With the clock ticking, teams compete to lift and deposit as many objects as possible, testing not just strength but finesse, timing, and coordination. Every successful grab reflects a balance of pressure, stability, and control, while failures expose weaknesses in design and execution.

This round represents the moment where ideas face reality. Delegates must adapt quickly, troubleshoot flaws, and optimize performance in real time. The Arcade Trial emphasizes resilience and ingenuity, pushing teams to refine their machines under competitive conditions and preparing them for the final round of optimization and mastery.

3. Round Name: Clawquest Showdown

4. Overview and Significance:

Delegates will design a functional hydraulic claw machine powered entirely by hydraulic systems. Delegates will use their understanding of fluid pressure and force transmission to create a claw that is capable of gripping and lifting objects smoothly and accurately using syringes and water instead of motors. The machine is expected to make a smooth, multi-directional movement, efficient gripping, and strong structural ability. This round emphasises both practical construction and conceptual clarity. Delegates should be well prepared to explain their design choice and the Hydraulic concepts involved.

Expected Outcomes:

a. Functional Machine:
    - The claw machine should move smoothly in all directions.
    - The claw must open and close properly to pick up objects.
b. Operational Performance:
    - Teams should be able to lift and deposit multiple toys within the strict time constraint.
    - Machines should operate stably without jerky movements.
c. Weight Handling Capability:
    - Machines should lift progressively increasing weights without breaking.
    - Structural reinforcements and weight distribution strategies should be evident.
d. Optimization & Efficiency:
    - Hydraulic pistons should move smoothly, with minimal friction.
    - Teams may demonstrate clever design solutions to improve grip strength, stability, or Motion efficiency
e. Design Innovation:
    - Machines should show creative and thoughtful design within the provided material
    - constraints
f. Theoretical Understanding:
    - Teams should explain the physics concepts applied.
    - Teams must justify design decisions and optimizations clearly.

5. Significance

This round is highly significant to the Engineering module because it directly translates core engineering principles into a practical, real-world application. Hydraulics is a fundamental concept used extensively in mechanical, civil, and industrial engineering - seen in cranes, excavators, car brakes, lifts, and heavy machinery. By replacing motors with syringes and fluid pressure, students gain an intuitive understanding of Pascal's law, force multiplication, pressure transmission, and energy transfer.

Additionally, the claw machine round strengthens essential engineering skills such as:

a. Mechanical design and structural stability
b. Understanding force, torque, friction, and center of mass
c. Optimization for efficiency and load-bearing capacity
d. Teamwork, time management, and iterative problem-solving

The round also emphasizes engineering thinking over memorization, requiring delegates to justify design choices and explain the physics behind them

Pre-Round Advisory

- Delegates are advised to finalize the design and working concept of their claw machine before the round.
- No dedicated time for designing or brainstorming will be provided during the event.
- Use of mobile phones, smartwatches, or external reference material is strictly prohibited.
- Only materials provided by the organizers may be used.

- **Debriefing & Orientation**
    - Core concepts of a hydraulically controlled claw machine are explained by the module heads.
    - Materials provided (cardboard, syringes, tubing, glue, etc.) are introduced.
    - Expected minimum functionality is clarified, including movement in all three dimensions and a functional gripping mechanism.
    - Safety guidelines for handling tools and syringes are communicated.
    - Judging process and elimination conditions are outlined.
    - A reference prototype may be demonstrated to convey expected performance standards.
    - No construction, cutting, or syringe filling is allowed during this period.
- **Building Phase**
    - Teams construct the claw machine using only the provided materials.
    - The base structure, arm, and claw mechanism are assembled.
    - Hydraulic systems are integrated by filling syringes with water, connecting tubing, and removing air bubbles.
    - Structural stability, smooth hydraulic motion, and proper grip functionality must be ensured.
    - Optimization measures such as reinforcing joints, improving weight distribution, and reducing syringe friction may be implemented.
    - At the end of 60 minutes, the structure is frozen, and no further physical modifications are permitted.
- **Testing Phase 1**
    - Each team is tested individually in a simulated arcade setup.
    - Two attempts of 1 minute each are provided to pick up toys and deposit them into a designated drop zone.

    - Toys of varying shapes and sizes are placed within reach of the claw.
    - Machines must demonstrate movement in all three dimensions during operation.
    - Teams that fail to demonstrate 3-axis movement or fail to lift at least one toy across both attempts are eliminated.
- **Testing Phase 2 and Judgement**
    - Qualified teams present their final claw machine models.
    - Judges inspect the structure, hydraulic layout, and overall stability.
    - Machines may be operated to assess smoothness, balance, and user experience.
    - Teams explain the working principle, physics concepts used, and design choices made during construction and optimization.
    - Overall performance, innovation, and robustness are evaluated.

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■ **Overview of evaluation:**

Delegates will be evaluated on their ability to design, build, and operate a hydraulically controlled claw machine that demonstrates technical accuracy, structural stability, and sound engineering judgment.

Judges will assess functional performance based on smooth, precise movement, reliable gripping, and controlled operation during object retrieval and lifting tasks. Consistent performance under load and stable motion are essential indicators of effective execution.

Technical execution is a key focus, including the strength and durability of the structure, effective weight distribution, and the efficiency of the hydraulic system. Machines are expected to be rigid, well-balanced, leak-free, and optimized using sound engineering practices such as triangulation and reinforcement.

Design quality and optimization are also taken into consideration. A clean, well-organized build that resembles an arcade-style claw machine and maximizes lifting capability through intelligent mechanical choices is highly valued.

Finally, delegates are expected to clearly explain how their claw machine works, including the hydraulic system, force transmission, and key physics principles used. Teams must justify their design and optimization choices, demonstrating genuine understanding rather than blind imitation.

■ **Provided Resources**

- Syringe
- Plastic tubes for connecting the syringes
- Cardboard Sheets
- Popsicle Sticks
- Transparent Tape
- Hot Glue Gun
- liquid glue
- Toothpicks
- Cutter Blade
- Zip ties
- Lubricating oil
- Thin pointed mobile screw driver
- Plastic Transparent PVC Sheet
- Round Hollow Plastic Tube

- Delegate Requirements:

  Delegates must use only the materials and tools provided by the organizers. Bringing personal resources or any external materials will result in immediate disqualification.

6. **The preparation and Study Resources**:

Category	Possible Resources
Topics to Study:	The main topics that will be tested in this round are fluid mechanics, force area relationships, and the behavior of incompressible fluids. Participants are expected to prepare by understanding the physics and engineering concepts behind

	a hydraulically operated claw machine.Key areas are pascals law and pressure transmission, the relationship between force and cross-sectional area, and basic hydraulic system behavior such as fluid continuity, air elimination, and pressure losses. Participants are also expected to be familiar with mechanical design principles such as claw shape, structural stability, and friction. Additionally, participants are expected to understand motion control and coordination, focusing on smooth actuation, precise multi-directional movement, and effective integration of materials, joints, and sealing methods used in syringe-based hydraulic systems.
Skills to Master:	Participants should aim to master a set of engineering practical and operational skills relevant to the hydraulic system. This should include the ability to assemble and adjust the hydraulic systems properly, eliminate air from the fluid lines, and maintain consistent pressure during the operation. Participants must also develop a strong mechanical awareness enabling quick adjustments to grip, alignment, and applied force during operation. Participants should also be familiar with motion control, emphasizing fluid and precise movement in multiple directions.
Essential Reading	https://hydraulicsonline.com/hydraulics-for-beginners?utm_source=chatgpt.com https://standardbots.com/blog/what-is-an-i ndustrial-hydraulic-robot-arm.com https://www.britannica.com/science/Pasca ls-principle.com
Inspiration Gallery:	https://youtu.be/KEs_h-ucJEs?feature=shared.com https://m.youtube.com/shorts/ZNbgbVRr- HU.com

Round 3: Breakpoint Offense

Delegation Cap(3 delegates)

1. Introduction and Summary

This module immerses delegates in the core principles of mechanical and electromechanical engineering, focusing on how theoretical physics and practical design intersect in real-world systems. Delegates will explore forces, motion, energy transfer, structural stability, and system optimization through progressively challenging hands-on rounds. Across the three rounds, delegates journey from conceptual understanding, to mechanical construction, and finally to system optimization and justification. Each round builds on the previous one, ensuring that by the end of the module, delegates can confidently design, analyze, and defend an engineered system under realistic constraints.

2. Round Description

a. Round Name: Breakpoint Offense

b. Overview and Significance:
The final round, “Breakpoint Offense,” focuses on the principles of mechanics narrowed down to the practical world of siege warfare combined with civil engineering. This round ensures that delegates understand how to apply physics principles in real-world engineering contexts, similar to ancient siege warfare engineers. Delegates apply engineering principles to both attack and defense while considering stability, structural strength, weight distribution, and stiffness. Participants are required to think like civil engineers while designing towers capable of defending against heavy impacts from opponent catapults.

Delegates will focus primarily on projectile motion, including horizontal and vertical range, structural stability, principles of tension, optimal launch angles to maximize range and speed, and the practical design of catapults. Understanding center of mass and efficient use of provided materials is critical in designing a tower that acts as a defensive castle. These structures will be tested for resistance to earthquakes and heavy loads, reflecting real civil engineering challenges. Delegates must also present an on-paper design and explain it, ensuring evaluation of both theoretical understanding and practical application. Structures must be presentable and fulfill all required tasks outlined in this study guide.

3. Step-by-Step Progression

a. It is recommended that at least three members from each delegation attend this round. Teams are required to design two structures within 90 minutes, both contributing equally to the final score; therefore, simultaneous work is encouraged. Complex materials are not heavily used, but uniqueness within the provided constraints is essential. For the tower (castle), only bamboo sticks and supporting materials will be provided. For the catapult, a medium-sized structure capable of launching heavy metal balls effectively is crucial. Delegates should prepare by researching optimal compositions beforehand. As this is a warfare-based challenge, teams must focus on both defense and attack, applying mechanics and civil engineering principles.

b. Phase 1: Designing and Planning:
It is compulsory to sketch designs for both the catapult and the tower. Artistic detail is not required; however, sketches must clearly correspond to the final structures. Delegates will be questioned on design choices and the physics behind each component.

Teams must decide:
- Width of the tower
- Height and number of stories
- Internal structural design
- Use of given materials
- Catapult setup angle
- Launch angle of the metal projectile
- Stability-enhancing features for both structures

Delegates should be prepared with the following concepts:
- Projectile motion
- Tension and ultimate tensile stress
- Energy conversion
- Stability and weight distribution (factors affecting stability)
- Gravity and air resistance
- Structural strength factors, such as triangular reinforcement within towers

These concepts will support both structural design and theoretical questioning. Delegates must understand how physics is applied at every stage of construction.

Phase 2: Build and Assembly:
Teams will be given 1 hour and 30 minutes to complete both structures. This includes:
- Full construction of the tower up to the required height
- Construction of a functional catapult capable of launching projectiles

The tower must withstand top-loaded stress, remain intact when toppled, and maintain stability under heavy shocks. The catapult must successfully launch a metal ball forward, prioritizing speed and range over height.

Phase 3: Testing:
Catapults and towers will be tested separately. Catapults must achieve a minimum range, tested by targeting a stack of cups. Each team will receive three attempts to knock down as many cups as possible using provided marbles, assessing blast radius and range.

Towers will undergo rigorous testing, including heavy load placement and earthquake simulation. Teams should ensure their structure survives to the final testing phase. Teams will randomly draw chits to determine which opponent structure they will attack.

Each team will attack the opposing structure three times using heavy metal balls.

During attacks, opposing teams are not allowed to repair structures unless they qualify for subsequent rounds. Disassembling catapults after initial testing is discouraged, as final designs should be selected within the allocated time. Winners are determined based on overall performance across all testing phases, not solely attack-defense outcomes.

Evaluation will include:
- On-paper design submission
- Explanation of theoretical physics concepts
- Structural uniqueness and physical attractiveness
- Proportionality and height of the tower
- Structural integrity after load and oscillation testing
- Projectile range, height, blast radius, and energy conversion efficiency

4.Provided Resources

- Shashlik sticks
- Styrofoam sheets
- Rubber bands
- Strings
- Hot glue gun
- Plastic spoon
- Tape

No external tools or materials are permitted. All resources will be provided, and any outside materials will be confiscated for fairness. Online consultation during the event is prohibited. Teams of three are preferred, with a minimum of two delegates. The maximum team size is three.
Only eight teams will qualify for the final round. The competition structure includes four quarterfinals, two semifinals, and one final.

5. Study Focus

Topics to study:
- Projectile motion
- Tension and ultimate tensile stress
- Energy conversion
- Stability and distribution of weight
- Gravity and air resistance
- Structural reinforcement techniques

Skills to implement:
- Tower width and height design
- Internal structural layout

- Efficient material utilization
- Catapult setup and launch angles
- Stability-enhancing design features

6. Reference Resources

https://youtube.com/shorts/maF4t8UYHog?si=v0xs4vJgFJ0i2KFu

https://youtu.be/iojDcLRC8Bw?si=g52q8jwEUgD0UsF-

https://youtu.be/UUJiDIzy_do?si=rXdk73gAPOTpUtsQ

https://youtu.be/l54rwegomUM?si=uiLJnbzWxUnyC4ja

https://youtube.com/shorts/E7vOXN6GCl4?si=RB7Z3YIZFoIDZPO0

https://youtu.be/8NLzuURxFwY?si=KIJ0lXzy2bmIEQ2J

https://youtu.be/JsU6PqfO14M?si=GFS5_gpmaOBs4rE9

This document serves as the complete and final guide for the final round. All procedures, resources, judging criteria, and differentiation strategies are outlined above. No additional information will be provided. Judging decisions are final and not subject to appeal. No extra time or attempts will be granted. Delegates are advised to prepare thoroughly, as construction is the only task on the event day, while testing procedures will be revealed only during evaluation.