TENNIS BALL SERVING MACHINE – Project assignment

GENERAL PROJECT DESCRIPTION

Design team is asked to design, build, and demonstrate a tennis ball serving machine that uses standard liquid CO2 3kg bottle as source of energy. The device must be capable of serving a regulation tennis ball from behind the service line to the opposite service court shown in Figure 1. The ball should pass over the net with as little clearance height as possible. Serves should alternate between corners C and D so that one serve lands in the quarter circle area C and the next one in the quarter circle D. The alteration between one and the other target should be automatic.

The machine should be of a reasonable size but shipping volume should be less than 500 x 500 x 1000 mm. It should be easy to assemble and use. The machine must be completely portable, preferably on wheels and independent of any external source of energy. If electrical power is to be used for any function of the machine it must be supplied from 12V batteries which will be provided. The machine must have ball storage capable of holding at least 12 balls. For launching a ball must be placed in the machine from the storage automatically. The operator should actuate the machine for each serve by use of a button, switch, or lever to initiate the serve. The energy storage and energy conversion system will be provided to the students along with the control systems. The materials supplied by the University will include a sheet of wood or metal and two electric motors. The remaining parts of the machine and the enclosure should be built within the budget of £50 per team. Purchasing of all required materials for this project will be responsibility of the students at their own costs. Therefore students should aim to spend as low as possible. All required materials should be ordered not later than the end of Week 5 in Term 2.

Manufacturing: When constructing the machine students should design it to be manufactured by the processes that students can perform on their own in the workshop. That includes cutting and drilling operations while milling and lathe operations are not allowed. Each group is allowed to manufacturing of one part produced by rapid prototyping and one part by CNC machining. Wood or metal cutting is limited to one sheet of 2000x1000 mm per a group. **The manufacturing plan needs to be handed and approved by tutors by the week 3 in Term 2 as a condition for manufacturing.**

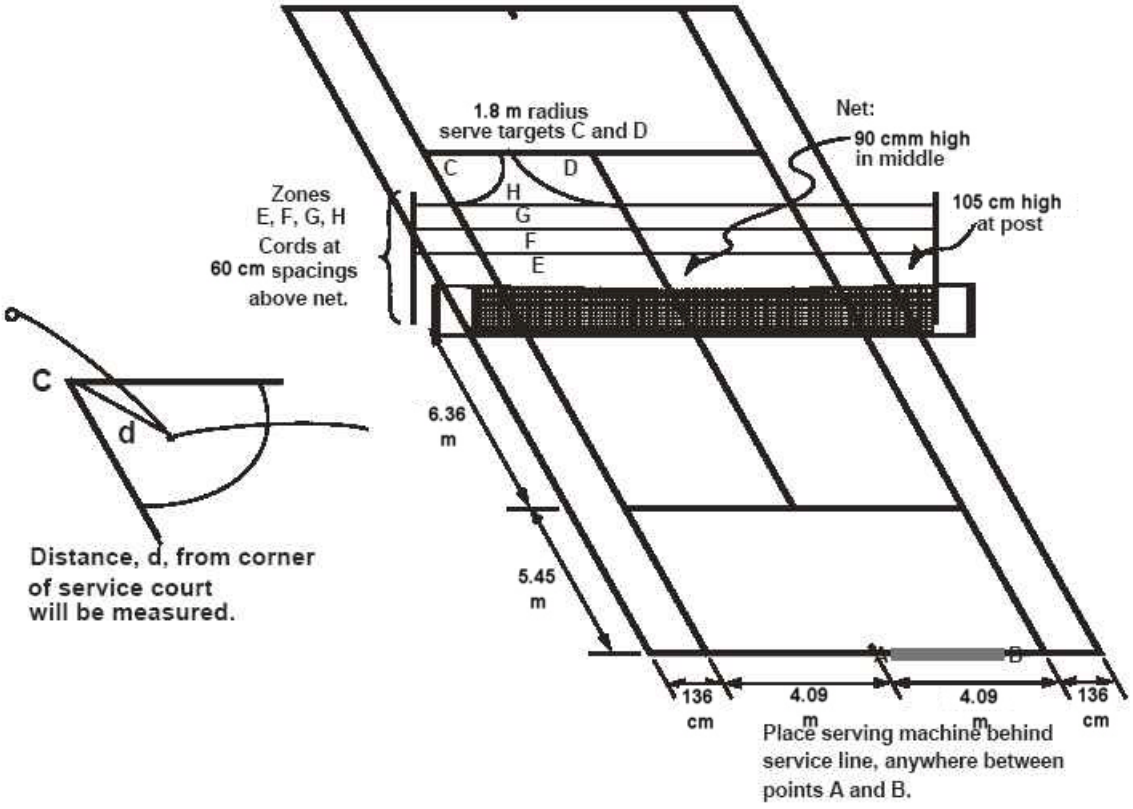

Figure 1 Standard dimensions of a tennis court

ADDITIONAL DEVICE CONSTRAINTS

1. The device must be safe. The design should reflect consideration for the safety of individuals operating it, holding it, or standing nearby.
2. The machine, plus any stand or structure must have a shipping volume of less than 500x500x1000mm. The combined weight of all machine elements including a stand must be less than 25 kg.
3. The machine, plus any stand or structure, must have a set-up time of less than 2 minutes.
4. The machine should be stable.
5. When serving, the machine and any stand or structure must be placed behind the service line.
6. The machine and any structure or stand must exhibit good workmanship in its construction, be painted or decorated, and have a team logo. Team may choose to build an enclosure for the machine
7. During testing, up to three serves are available for each landing area C and D. These should alternate between each other. The serve should get as close as possible to the corner. For each serve, the distances dC and dD from each corner will be measured. The shortest distance will be used in the Figure of Merit (FOM).
8. The balls should travel as low as possible over the net, like a good tennis serve. "Zones" E, F, and G will be established by stretching cords above the net at 2 ft intervals. (There will be some sag in the cords.) Zone H will be above the third cord. The Figure of Merit equation will be multiplied by a factor of 1.1 for a ball passing through zone E, 1.0 for zone F, 0.9 for zone G, and 0.8 for zone H (anywhere above the top cord). If on any serve a team's ball strikes a cord, that serve may be re-served with no penalty.
9. The machine must automatically alternate between two targets
10. Materials to be provided by the School are listed in the Appendix.
11. The total cost of materials used to construct the machine and any stand or structure is limited to £50. The cost of materials must be completely and accurately documented.
12. The machine must exhibit significant design creativity and/or innovation. (Note: This requirement is intended to prohibit solely commercial or off-the-shelf solutions to the problem.) The design instructor will make the final determination as to whether this requirement is met.

FIGURE OF MERIT

Teams will have 6 servers to set the machines before testing. After the machine is set, no manual adjustment of the machine will be allowed during testing. Testing will consist of 6 serves alternating between two targets,

The performance of the serving machine will be computed by the following figure of merit (FOM):

$$FOM = Z \cdot \left[10 \cdot (50 - C) + 100 \cdot \left(1.8 - \left(d_C + d_D \right) \Big/ 2 \right) + 100 \cdot T + 20 \cdot (25 - W) \right] + 20 \cdot A + 20 \cdot E + 200 \cdot DI + 30 \cdot OI$$

Where:

Z Multiplier based on above net zone ball passes through
Z=1.1 for zone E, 1.0 for zone F, 0.9 for zone G, and 0.8 for zone H.

C Cost of materials in £

d_C, d_D Minimum distances (m) from the corner of service court to the ball landing location for best serves.

T Total number of tries to hit landing zones C and D

W Total weight of machine plus any stand or structure needed (kg)

A A number ranging from 0 -4 assessing the workmanship and aesthetic appeal of the machine. Aesthetics also includes the ease and reliability of operation.

E A number ranging from 0 - 4 assessing the ease of set-up and use of the machine.

DI A number ranging from 1 - 4 measuring the creativity and/or innovation of the design. The innovation will be evaluated for sealing, aiming, feeding and storing of balls.

OI A number ranging from 0 - 4 assessing the quality of the operating instructions.

DELIVERABLES

1. In addition to the prototype that is tested, teams must also document and report on their progress as well as provide a final report on the project.
2. Teams will provide weekly memo reports documenting their progress.

3. Teams will have three design reviews, and the final presentations on dates specified in the Timetable.
    a. Project review 1 – Vision & Concepts (Report and PPT Presentation)
    b. Project review 2 – Embodiment (Report and PPT presentation)
    c. Project review 3 – Detailed design (Report and PPT presentation)
    d. Final report – 'Dragons den' (Prototype, Report – Marketing, business, technical, PPT presentation, poster and user manual)
4. A user's manual for the device detailing assembly, disassembly, and operation of the device must be made available at the time of testing.
5. A final report documenting the entire project from initiation to completion will be required at the completion of the project.
6. Each team will be required to deliver a computer-based presentation of their project around the time of testing. This will be a sales-oriented presentation designed to convince the instructor that their device is worthy of purchase.

TECHNICAL DETAILS

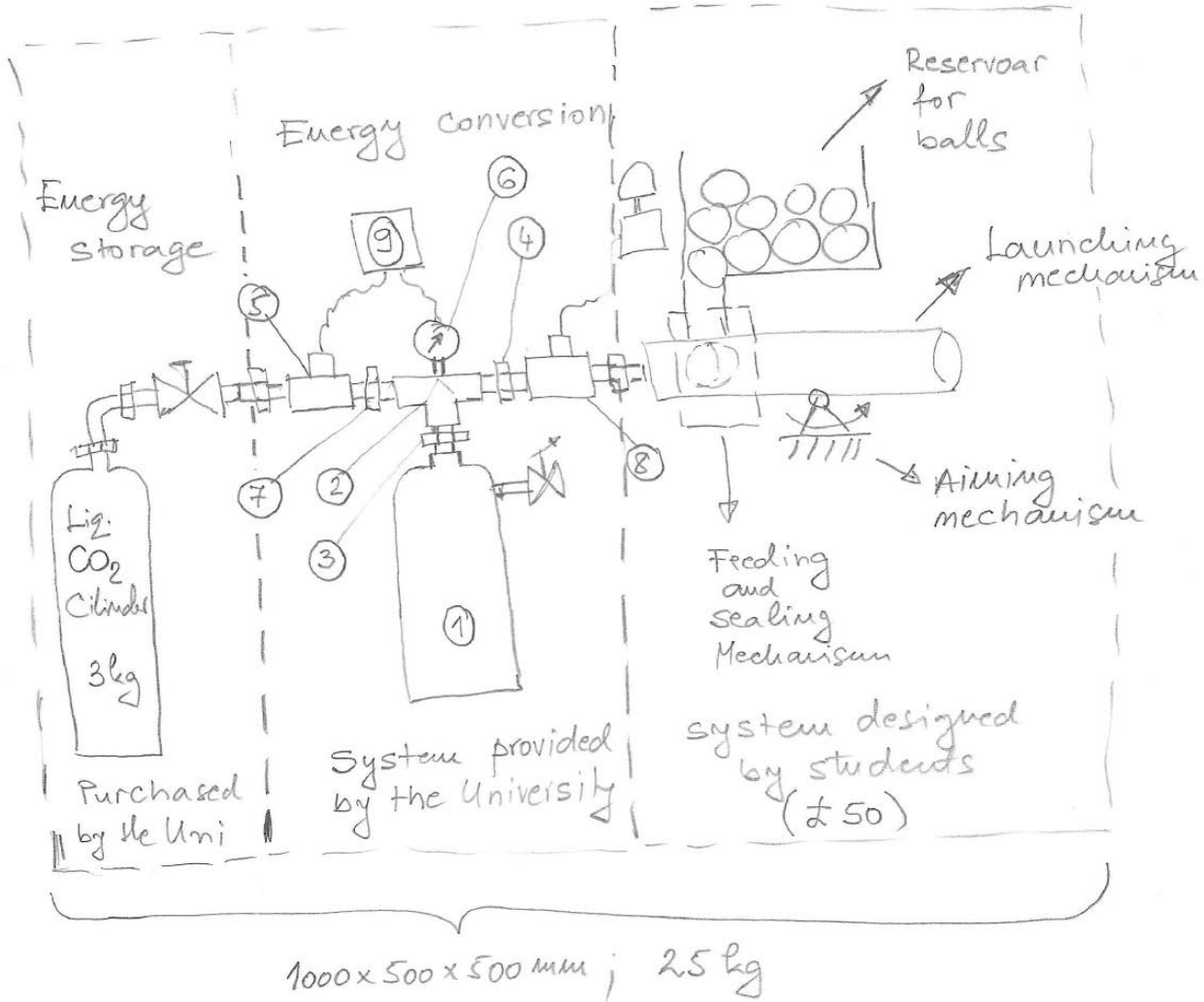

Figure 2 Schematic view of a tennis ball server wth compressed gas

1) CO_2 fire extinguishers to use as pressure vessel
2) BSP T piece 1"
3) 1" BSP male – 3/8"BSP female bush
4) 1" BSP male/male nipple
5) 10 bar 3/8"BSP female solenoid valve
6) 0 - 10 bar pressure gauge
7) 3 x 3/8"BSPP male /male fittings
8) 1" BSP Rinpro 200 series solenoid valve
9) Pressure control system

The energy conversion components will be provided to each student group assembled as shown in the diagram below.
The energy storage will be provided for testing purposes.

The source of energy for this project will be compressed CO2 stored as liquid in bottle of 3 kg charge. (Figure 3) Alternative energy source will be compressed nitrogen cylinder with pressure reduction valve and 2 meters extension hose. If this is used the same connection as for CO2 bottle for direct filling of the tennis ball server will be provided. The designs of tennis ball server should allow for a convenient position of the connector for the N2 bottle in case that energy source is used.

In the conceptual design groups should consider design of the entire tennis ball server but additional attention needs to be drawn to the regulation of the filling of 'internal reservoirs' (CO2 bottles), firing process for multiple balls, sealing and aiming of the ball to the required target.

Figure 3 Standard 3kg liquid CO2 bottle