**Warman Design Project**

**Team 42**

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# Product Design Specification (PDS)

Functional Requirements:

* System must be able to carry 10 Wilson Tour Competition Tennis Balls which have a diameter of 6.75cm.
* The system must also be able to deposit these 10 balls into 4 different vessels, which vary in height from 80mm to 300mm.
* System must be autonomous, cannot have any physical contact with any team members or use any wireless systems to alter its path.
* The system must navigate around or over obstacles on the track, which include a PVC rod and the 4 vessels.

Other Requirements:

* System cannot exceed a mass of 6kg.
* Initial total cubic volume of 500mm x 500mm x 500m.
* System must leave the start/end zone, navigate through the 2.4m x 1.2m track, complete the deposit functions and return to the start/end zone in under 120 seconds.
* The system cannot have any untethered flying systems, and at any given time a part of the system must be in contact with the track.
* Considering the spirit of the competition, the system must be built using off the shelf parts (excluding LEGO), meaning an established system cannot be bought, although parts may be modified.
* Must be started by a single action by a team member without imparting energy (such as pushing).
* System cannot leave parts behind on the track apart from the payloads.

Design Objectives:

* Minimise the time it takes to complete the requirements set out by the Warman Design Competition.
* Maximise the safety precautions such as by conducting risk assessments and testing, to minimise risks to spectators and potential users.
* Minimise the cost of production, to reduce the associated number of parts and difficulty of assembly.
* Minimise the steps of manufacturing so assembling the system is easier.

**Problem Statement**

Move Device > Secure Balls > Avoid Obstacle > Deposit Balls > Control Motion > Return to Start

# Morphological Matrix

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sub-problem | Sub-problem Alternatives | | | | | |
| Depositing | A drawing of a person  Description automatically generatedRobotic Arm | A picture containing water, flying, air, drawing  Description automatically generatedCrane | A close up of text on a white background  Description automatically generatedCylindrical Container | A close up of text on a white background  Description automatically generatedBox Container | A necklace with a piece of paper  Description automatically generatedSpiral Tube | A drawing on a necklace  Description automatically generatedProjectile canon |
| Storage | A picture containing text, towel  Description automatically generatedHopper | A close up of text on a white background  Description automatically generatedCylindrical container | A picture containing drawing  Description automatically generatedDispenser | A necklace with a piece of paper  Description automatically generatedSpiral Tubes | N/A | N/A |
| Providing Support | Wheels  A picture containing chain, necklace, water  Description automatically generated | A picture containing drawing  Description automatically generatedTracks | A picture containing outdoor, water, snow, white  Description automatically generatedSkis | A necklace with a body of water  Description automatically generatedBalloon Tyres | A drawing of a face  Description automatically generatedMecanum Wheels | A picture containing water, man, holding  Description automatically generatedOmni-directional wheels |
| Power | A close up of a device  Description automatically generatedElectric Motor | A picture containing text, drawing  Description automatically generatedPetrol Engine | A picture containing text, drawing  Description automatically generatedDiesel Engine | N/A | N/A | N/A |
| Transmitting Power | A close up of a logo  Description automatically generatedGears | A picture containing man, airplane, water, table  Description automatically generatedHydraulics | N/A | N/A | N/A | N/A |

# Pugh’s Matrix 1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Categories | A picture containing black, woman  Description automatically generatedConcept A (Baseline) | A close up of text on a black background  Description automatically generatedConcept B | Concept C  A close up of a blackboard  Description automatically generated | A close up of a blackboard  Description automatically generatedConcept D | Concept E  A picture containing game  Description automatically generated |
| Stability | Not great because it only has 1 pillar to stand on. Could add more.  N/A | Scissor mechanism not very stable. Could make it a double scissor mechanism.  -VE | The arm of the robot could change the Centre of Mass, otherwise quite stable.  +VE | Centre of Mass would change due to extending arm. Only 1 pillar joining chassis and mechanism, thus unstable.  -VE | Quite stable due to the position of the wheels.  +VE |
| Accuracy | Fixed height, therefore, not great because payloads could bounce out of the drop-zones.  N/A | Quite accurate due to a varying height.  +VE | Very accurate, considering the code for the arm is done correctly.  +VE | Accurate due to the extending arm.  +VE | If the wheels align themselves properly, it could be accurate.  EQUAL |
| Speed | Tracks would be slower, and they will take time in aligning with the drop-zones.  N/A | Scissor mechanism could take time winding and unwinding, and gates could take time opening.  EQUAL | Relatively quick, deposits fast, however it will take time to put the tubes back.  -VE | 5 motors so would be quick.  +VE | Would need to slow down when going over the obstacle.  EQUAL |
| Buildability | Depositing Container hard to build.  N/A | Depositing container hard to build, as well as scissor mechanism.  -VE | Difficult to code the robotic arm and make it precise.  -VE | Lots of mechanical parts, so had to build.  -VE | Design could be heavy, so materials cost and difficult to get the top part right.  +VE |
| Cost | Expensive due to multiple complex parts.  N/A | Quite costly due to the depositing container, as well as the scissor mechanism.  +VE | Could be very expensive due to the robotic arm.  -VE | Expensive due to the depositing container and multiple motors.  -VE | Fairly reasonable as there isn’t many complex mechanisms.  +VE |
| Overall | N/A | 0 | -1 | -1 | 3 |

# Pugh’s Matrix 2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Categories | A close up of a blackboard  Description automatically generatedConcept A (Baseline) | A picture containing game  Description automatically generatedConcept B | A close up of a logo  Description automatically generatedConcept C | Concept D  A picture containing racket, player  Description automatically generated |
| Stability | Fairly Stable, due to double scissor mechanism. Potentially unstable whilst depositing. Could enlarge wheels.  N/A | Fairly stable, could enlarge wheels for more stability.  -VE | The mass of the robotic arm while depositing could alter the Centre of Mass of the system, otherwise stable.  -VE | Very Stable due to wide wheels.  +VE |
| Accuracy | Fairly accurate, if it aligns itself with the drop-zones.  N/A | Could be inaccurate for drop-zones ‘A’ and ‘B’, due to the inability to change height.  -VE | As long as the code for the robotic arm is done correct, it will be accurate.  +VE | Fairly accurate, due to varying height.  +VE |
| Speed | Scissor mechanism could take time to wind and unwind, otherwise quick.  N/A | Quite fast due to low mass and multiple motors.  +VE | Robotic arm may take time aligning itself with the drop-zones, otherwise fast.  -VE | Rollers with aligned tread means it doesn’t have to jump over the obstacle.  +VE |
| Buildability | Easy to build apart from the scissor mechanism.  N/A | Not many complex systems so should be easily buildable.  +VE | The robotic arm would be hard to code  -VE | Difficult to build due to multiple complex systems i.e Rollers with aligned tread, scissor mechanism and depositing box.  -VE |
| Cost | Scissor mechanism, motors and microcontroller may increase the price but within reasonable range.  N/A | The middle segment could be costly to build, maybe 3D print.  EQUAL | Costly due to the Robotic arm and the large support wheels.  -VE | Lots of complex mechanisms means a high cost.  -VE |
| Overall | N/A | 0 | -3 | 1 |