MICROMITE – Ball in a Maze Puzzle



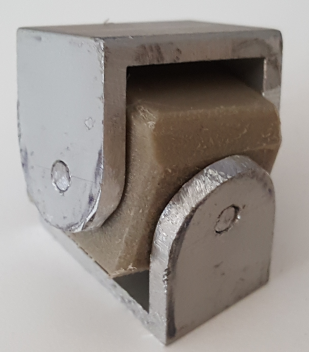
**Ball-in-a-Maze** is a skill performing puzzle involving controlling a metal ball through a labyrinth so that the ball is manoeuvred towards a finish goal creating a challenging fun activity for you and your friends. There are many types of Ball-mazes on the internet, but most are using manual means to move the maze table. In this project, you will navigate the steel ball to the finish line (or hole) by moving the maze swivel base using a joy-stick controlling 2 micro servo motors.

This game will test your skills, sanity and patience; and to master this game, you will not only need to be focused on the correct ball positioning, but you will need agility and mainly hand to eye coordination if you don’t want the ball to end up in the wrong hole.

The course is split into 6 different stages of similar distance, each one having a proximity sensor registering the time taken to reach each one. If the time taken to finish a stage is less than any previously achieved saved time, the LED will confirm this as a \*\* NEW RECORD \*\* and save it so that only the best times are always visible when requested.

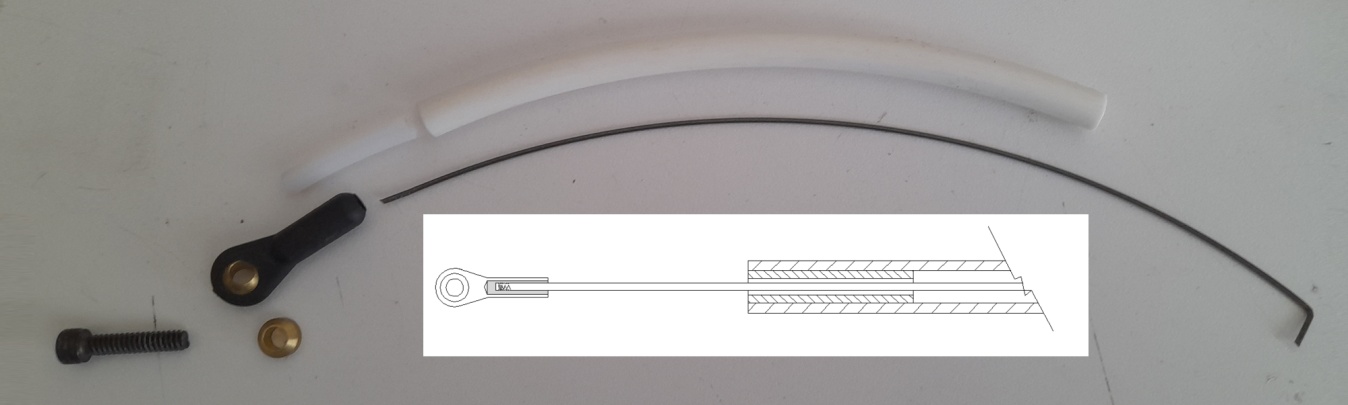
**Diagram, schematic

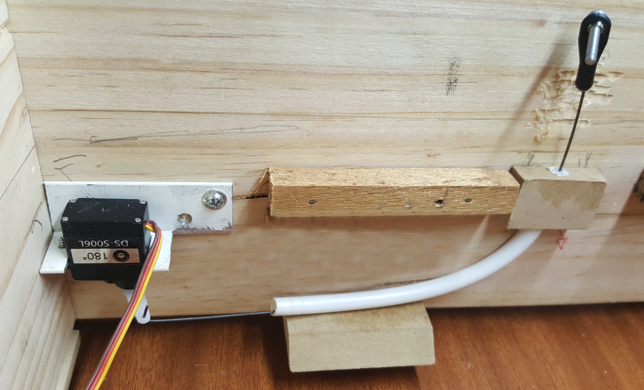
Description automatically generatedPlaying** - when powered up, the table will automatically tilt so that the ball can be placed safely in the START area and the LED display will ask if to show the current saved top scores or to start the game, this by either moving the Joystick back or forward. The MicroMite will then either display the 6 stage scores in set order of 1-2, 3- 4 and 5- FINISH or signal to get ready to play. If play is selected, the table will level and the control is then passed on to the user via the Joystick. If the ball is lost, the computer will ask if to start a new game. Pushing down the Joystick will confirm restarting.

**** **Fabrication** – the most complex part in building the maze is the actual Maze tilting board. Once the plywood base is ready cut to size, sand down the top face so that a good smooth surface is achieved. Then use the Left and Right layout template to trace each barrier and holes locations on the worked face. The template can be printed on 2 x A size pages and taped together to form the full square using the long black line as alignment reference. Proceed then in drilling the 31 holes and the opening windows for the Optical Sensors; glue the 4 side and all the barriers to the Maize Base making sure that the barriers with the 8x4 blind slot housing the Optical Sensors are correctly located. Proceed then in placing the assembled Optical PCB boards and the locking male connector. Once all wires are soldered according to the Schematic, apply hot-gun glue to lock them in place. Mark the centre of the board and glue the predrilled Holding Blocks. These will be used to hold the Universal joint via the Intermediate Block.

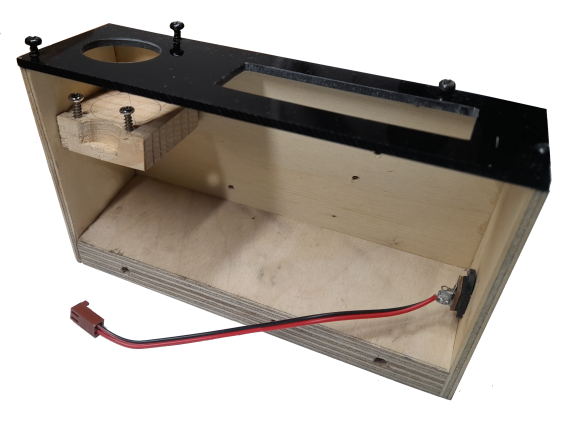
The Universal Joint is fabricated using 2 aluminium 25x25 U channel cut and shaped as shown on the drawing. The connecting block is made from Nylon or any other suitable material. The 4 pins will join the 3 components together. Make sure the joint can move freely and adjust if these interfere with the movement when fully assembled, then connect to the intermediate block and cross braces, there will be a need to cut shorter the M4 screws length as required.

Once the outer frame of the Main Box is complete, the 3 Universal Joint Braces are glued together to the small shaped Brace Plate and then the 2 holes drilled. Once screwed to the main box through the already drilled locating holes, these can be used as line reference for the location of the sloping plates retaining strips.

The 2 Servo Motors can be fastened to the aluminium bracket and screwed at the 2 corners of the box. Before the Nylon sloping Retainer and Supports are fixed into place you will need to fabricate the 2 wire links.

For these, we will use a short length of Ø 0.9mm Piano Wire and a slighter larger Nylon tube as guide sleeve. One end of the Piano wire will need to be bent at 90° for about 5mm to suit the Servo Motor lever, while the opposite end should be knurled/pinched using a side cutter so to improve adhesion when placed in the Swivel ball link. The wire is then pushed through the larger nylon tube and the short and smaller diameter tube inserted into it, now the knurled end of the wire can be glued into Swivel Ball link using an epoxy adhesive. Once the epoxy is dried, the link can be attached to the Servo Motor and the wooden Tube Retainers and Supports can be glued to the box sides locking the tubes in place. The additional smaller nylon tube and the retaining and supporting blocks will assist in achieving a good up-down linear movement.

The Main Box, Universal Joint with the Supports and the tilting board can now be assembled together, leaving only the sloped boards and ball collector to attach. The Ball Collector must be screwed to the main Box first and once the Servo and Braces interfering areas on the 2 boards A and B are cut, these can be slide in and locked in place using the hot-gun glue as fastener. Trim these boards further if some interference with other already installed components is present. Use small intermediate blobs, just in case these need to be removed again for possible further adjustments.

A small clear plastic box can be cut in half to create the external collecting box. This can also be affixed to the main Box using hot-gun glue.

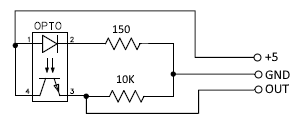
The fabrication of the electronic control box is straight forward; attention is required when gluing the Joystick timber base as this needs to perfectly match the covering Perspex round opening. The 15mm thick base allows for the Control Box to be fastened to the Main Box by 2x 10Gx 35mm long self tapper screws. The PCB and the LCD Display can be either locked in place by using double sided tape or additional small screws.

Once all assembled, the black strips screening the Optical Sensors from external light can be glued to the barriers top edge. Stage Labels can be added later. Finally and if needed, the bottom of the Main Box can be enclosed with a 350x350 plywood sheet.

**The Electronic** – The main electronic circuit runs on the MicroMite 44 pin, this due to the limited number of pin on the smaller 24 pins model. Added to this, are the 16x2 LCD display, the 2 Servo Motors and the mini Joystick.

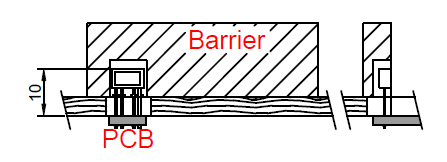
Run few tests to determine the correct values for the Xoffset and Yoffset before installing the Control Box to the Main Box. This is required so to obtain the correct horizontal position for both axes when starting.

Note: Changing part of the program will always require the Control Box to be open so the Console terminal connection can be reached.

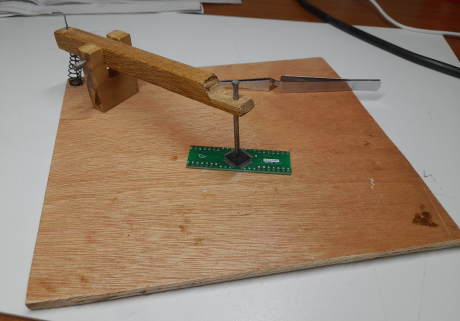
The whole circuit runs on a 5V supply via a surface mount Male DC Socket, with a MCP1700T-330 Voltage Regulator supplying the 3.3V to the MM.

The Optical Sensors Resistors use the 5V compatible Analogues Pins of the MM with both resistors values balanced so that the correct V required to trigger the MM Digital input threshold on these pins can be reached. R150 value is selected so to achieve best LED light while the R10K is selected so to achieve high output voltage.

The OptoLOST uses a separate connection as this is not placed on the tilting board; this also allows using possible alternative sensors such a Paper Sensors (eg. PS126EL1) recovered from an old stripped printer, which would require the 2 resistors to be mounted separately on the PCB.

Although the TCRT1000 sensors have Daylight Blocking filters, these are still sensitive to some ambient light and triggering may occur when exposed to different light orientation. By covering the area with a thin black plastic strip and by painting black the Ball collector and external tray areas will assist in avoid incorrect triggering.

When soldering the Opto Board components start with the 2 small SMD resistors and attach the sensor for last. The TCRT1000 Sensors must be soldered so that the sensor top edge is about +10mm from the PCB face.

Similarly for the main PCB, start with the 44 pins MM, making sure the pin 1 is correctly located, and work through the SMD components, then use the thin stripped single strain cable to create the ‘static vias prior attaching the toll headers. One easy way to solder small SMD components is to use a home-made spring-loaded jig. This will avoid any possible movement when soldering. The soldering could be some messy due to the close proximities of the pins, but any excessive solder can be easily removed using a Desolder Braid (Solder Wick).

The Joystick is connected to the 3V Analogue Pin(26) and Pin(27) as the voltage value output from the Joystick is what determines the Servo pulse width. The 2 Servo Motors and the LED Display are powered directly by the 5V input. The Servo Motor operating the Y axes will require to manufacture a short extension of about 300mm. When connecting the extension cable to the Y-axes Servo, please take note of the correct cable colours so to avoid incorrect polarity connection onto the PCB board. Remembering that the wiring from the Servo are Red (+5V), Black or Brown (GND) and Yellow or Orange (Pulse input).

The MM program to tilt the Maze Board firstly works out a mid range of the movement using the X and Y Joystick V outputs values (these between 0V to 3.3V), multiplies these by a VKonst (usually 0.5) and then adding the minimum Pulse Width of 0.5 (PWMin). The Yoffset and Xoffset are then further added to achieve correct board horizontal balance.

The Optical Sensors activate the 7 INTH Interrupts, with the first 6 used to confirming when each stage is reached and with the 7th (OptoLOST) calculating the best time taken to achieve a stage, and if reached comparing to what already saved and if timing bitten, saving the updated results. Alternatively, just to confirm game lost and give option for a new game.

The PCB Board is designed to allow home user to print on a double-sided PCB and have the ‘via’ links manually added using a thin copper wire such as the one used for telephone cables. The Ball Maze PRO\_gerberx2 with is also included for professional ‘via’ manufacturing.