Table‑Top Maze Solver Robot Project Plan

# 1. Bill of Materials (Hardware)

|  |  |  |  |
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| Qty | Item | Notes & Specs | Typical Cost (USD) |
| 1 | Raspberry Pi 4 Model B (2 GB+ RAM) | On‑board Wi‑Fi/BT, 40 GPIO pins | 45 – 60 |
| 1 | micro‑SD card (16 GB+) | Pre‑flash with Raspberry Pi OS Lite | 6 |
| 1 | Dual‑motor driver (TB6612FNG or L298N) | 1.2 A peak/channel; 3‑5 V logic | 4 – 8 |
| 2 | 6 V mini DC gear motors (≈150 RPM) | Metal or plastic gearbox | 6 ea |
| 2 | Wheels (65 mm) & wheel adapters | Matches motor shafts | 5 pair |
| 1 | Caster ball or omni‑wheel | Front support | 3 |
| 3 | IR reflective line sensors (TCRT5000) | AO+DO pins; 3.3 V | 1 ea |
| 1 | Raspberry Pi Camera v2 or HQ Camera + lens | 640×480 @ 60 fps fine | 15 – 25 |
| 1 | Power bank (5 V @ 2 A min, 10 000 mAh) | USB‑C → Pi; USB‑A → 5 V DC/DC for motors | 15 |
| 1 | DC/DC “buck” converter (5 V → 6–7 V) | Feeds motor driver | 4 |
| — | Assorted M3 screws, spacers, standoffs | Mount Pi & camera | 5 |
| — | Dupont jumper wires, mini breadboard |  | 3 |
| — | Poster‑board maze | White foam core + black tape tracks | 2 |
| — | AprilTags or QR codes | Print 4–5 cm squares on matte paper | 1 (ink) |

Estimated total hardware budget: \*\*~$120\*\* if you need a Pi, or \*\*~$70\*\* if you already own one.

# 2. Software & Libraries

|  |  |  |
| --- | --- | --- |
| Layer | Choice | Install Command |
| OS | Raspberry Pi OS Lite (32‑bit Bookworm) | — |
| GPIO | pigpio daemon | sudo apt install pigpio python3-pigpio |
| Motor & sensor helper | gpiozero | pip install gpiozero |
| Vision | opencv‑python (>= 4.10) | pip install opencv-python |
| AprilTag | apriltag (RustPort) or pyzbar | pip install apriltag |
| Graphs & search | networkx | pip install networkx |
| Data & plotting | numpy, matplotlib | pip install numpy matplotlib |
| Dev‑ops | ssh, git, tmux | sudo apt install git tmux |

# 3. Wiring at a Glance

Pi TB6612FNG IR Sensors (x3)  
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5V ──┬─► Vcc 3V3 ─► Vcc  
 │ GND ─► GND  
 └─► 5 V buck → motors AO ─► MCP3008 (if using analog)  
GND ─────► GND DO ─► GPIO 17/27/22  
GPIO 18 ─► PWM A (motor L) EN ─► GND (always on)  
GPIO 23 ─► DIR A  
GPIO 13 ─► PWM B (motor R) Pi Camera → CSI ribbon connector  
GPIO 24 ─► DIR B

# 4. Roadmap & Milestones (≈ 3 weeks)

## Week 0 — Setup & sanity checks

* Flash Pi OS Lite, enable SSH & camera (raspi-config).
* Update/upgrade, install libraries.
* Blink an LED with gpiozero (verify GPIO).
* Test camera feed with libcamera-hello.

## Week 1 — Chassis & dead‑simple drive

* Mount motors & wheels on chassis; add caster wheel.
* Wire motor driver & buck; write 20‑line drive test.
* Tune PWM for straight travel.
* Mount Pi, tidy cables, untethered drive test.

## Week 2 — Line following & tag detection

* Install three IR sensors; set spacing & height.
* Calibrate thresholds; write proportional line‑follower.
* Print AprilTags; run detection script, measure FPS.
* Integrate: stop on junction → read tag → print ID.

## Week 3 — Graph build & search

* Implement Graph class using NetworkX.
* Add nodes/edges on each new junction with length ticks.
* Implement BFS (shortest path) and DFS fallback.
* Loop: if current==goal stop; else move along next edge.

## Demo polish (2–3 evenings)

* Live Matplotlib graph of discovered maze.
* Add CLI flag --goal TAG\_ID for dynamic replanning.
* Record split‑screen demo video.

# 5. Suggested Folder Structure

maze\_bot/  
├── hardware/  
│ └── wiring\_diagram.fritzing  
├── python/  
│ ├── motor\_driver.py  
│ ├── line\_follow.py  
│ ├── tag\_reader.py  
│ ├── graph\_builder.py  
│ ├── search\_algos.py  
│ └── main.py  
├── tests/  
│ └── test\_search.py  
└── docs/  
 └── report.md

# 6. Tips That Save Hours

* Iterate in emulation first — mock sensor inputs to debug search logic.
* Use timestamps instead of encoders for initial edge weights.
* Set up a laptop Wi‑Fi hotspot for demos on‑the‑go.
* Keep a spare power bank charging to avoid downtime.

Good luck building and demoing your maze‑solving robot!