Matter Stack — Execution Checklist & Gate Criteria

Buy → Build → Measure → Prove → Unlock the next stage

Companion to the Matter Stack Compendium (Parts I–VII). Same rules as the Magnetic Matter Movers Phase 0 checklist: print it, fill it in ink, photograph the filled pages + videos as your gate evidence. Unexplained deviation fails a gate; explained deviation is data.

Shared-hardware note: the Stage 1 acoustic layer IS the TinyLev from Magnetic Matter Movers Build Sheet 002 — one levitator serves both projects. Buy once; the polarity-test discipline here is the same skill as Halbach polarity marking in Build Sheet 001. These projects train each other.

Stage 1 — The 4×4 Base Build (~$332, 3–5 weekends)

1.1 Purchase

☐ Makerfabs Acoustic Levitator kit ($70) — or scratch parts per Compendium §6.1 ☐ 16× 12 V electromagnets 25 mm ($64) · 16× IRLZ44N MOSFET modules ($18) · 1N5819 diodes 100-pk ($7) ☐ Arduino Mega clone ($18) · 12 V 10 A PSU ($16) ☐ Ferrotec EFH-1 50 ml ($30) · glass cell + lid ($10) · distilled water + salt ☐ Polystyrene beads 1–3 mm · teabag paper/mesh scoop · perfboard/terminals/18 AWG ($14) ☐ Gloves + plastic sheeting ($8) · mini projector ($60) · gantry print ☐ Verify owned: soldering iron, multimeter (mandatory), phone tripod

1.2 Build A — Acoustic (order matters: acoustic first)

☐ Frame printed, sockets filed to snug press-fit ☐ **Polarity test EVERY transducer** (A0 + Serial Plotter); + leg paint-marked BEFORE soldering → Record: transducers tested **__ / inverted-marking count** ____ (builders report this is common — your number is real data) ☐ Arrays populated, epoxied (not hot glue), bussed; continuity: every +→+ bus, −→− bus, no bus-to-bus short ☐ Nano flashed, L298N wired; Nano powered from USB **or** L298N 5 V — never both ☐ Optional scope check: both arrays in phase

1.3 Build B — Magnetic

☐ Saturated saline mixed & settled; cell filled ⅔ saline + 10–20 ml ferrofluid injected below surface; **lid sealed** ☐ Hand-magnet test through glass (spiking observed — calibrates intuition) — done gloved, over sheeting ☐ 4×4 grid mounted at ~30 mm pitch, coils labeled 1–16, leads to terminal strip ☐ **Flyback diode across every coil, stripe to + lead — count them: ______ /16 before first power-up** ☐ One MOSFET per coil; coil rail separate from Arduino rail, grounds tied at one point; rail fused ☐ Firmware duty cap set at ______ % (spec: 60–70%)

1.4 Stage 1 — Actual vs. Predicted

Measurement	Predicted / spec	Actual	Dev./notes
Bead levitation duration	≥ 5 min stable	______	___
Bead vertical move via phase shift	smooth, no drop	______	___
Levitation supply voltage	works at 6–9 V	______ V	___
Single coil 50% duty	one smooth bump	______	___
Traveling bump (cross-fade demo)	full orbit, no tearing	______	___
Tear-speed (max bump travel speed)	*characterize — YOUR number becomes the spec*	______ mm/s	—
Coil current, one coil full duty	0.3–0.5 A	______ A	___
Coil temp after 10 min @ 50%	warm, touchable	______	___
Two-layer milestone	bead above + bump tracking below, one host	______	___
Full-stack milestone	3 layers synced from one script	______	___

Triage: no levitation → re-verify polarity of suspect transducers, try smaller/irregular bead, drop voltage slightly · bead ejects → voltage down · no bump → coil polarity/wiring, cell standoff >8 mm · bump jumps instead of glides → PWM cross-fade logic, not hardware · anything dies at MOSFET switch-off → a missing flyback diode, stop and audit all 16.

GATE S1 — pass: ☐ 5-min levitation video ☐ traveling-bump orbit video ☐ full-stack sync video ☐ table filled, tear-speed recorded ☐ diode count photo ☐ anomaly paragraph per >50% deviation. **Unlocks Stage 2 purchasing.**

Stage 2 — 8×8 Upgrade (~$392 delta, +mic & cooling)

2.1 Purchase

☐ 64× electromagnets ($200 — or reuse 16, save ~$46) · 64× MOSFET modules ($60) · 4× PCA9685 ($20) · extra diodes ($7) ☐ 12 V 30 A PSU ($32) + fuse · heatsinks + fans ($28) · USB mic ($25) · 16 AWG distribution ($20)

2.2 Build

☐ 64 coils at ~15 mm pitch; cell standoff 3–8 mm; PCA9685 addresses 0x40–0x43 jumpered, I²C chained ☐ Per-coil MOSFET + flyback retained — **diode count: ______ /64** ☐ Bus bars 16 AWG+, rail fused; fans wired to run whenever coils energized ☐ Firmware: duty cap, simultaneity cap ("max hot coils": ______), per-coil dwell limit set

2.3 Stage 2 — Actual vs. Predicted

Measurement	Predicted	Actual	Dev./notes
Separable terrain features	8–12 (fluid physics, not coil count, sets ceiling)	______	___
Re-measured tear-speed (finer grid)	differs from Stage 1 value	______ mm/s	___
Total current, typical scene	well under 30 A fused	______ A	___
Coil-bank temp, 30-min run w/ fans	stable, not climbing	______	___
Sound-reactive demo	bass→center swell, onset→bead dart	______	___
Existing scenes on denser grid	run unchanged (normalized coords)	______	___

GATE S2 — pass: ☐ feature-count photo with count annotated ☐ 30-min thermal log ☐ sound-reactive video ☐ table filled. **Unlocks Stage 3 or the art-piece fork (a gallery-ready machine legitimately stops here at ~$724).**

Stage 3 — MATD Phased Array (~$425 delta)

Compendium warning stands: attempting this first is the most common project-killer. Entry condition: Gate S2 passed.

☐ Flat array 64–256 transducers (Ultraino/OpenMPD route); **every transducer polarity-tested** — same discipline, larger scale ☐ Phase controller (FPGA/MCU + driver boards) brought up ☐ **Static trap first** — reproduce a stationary hover before any steering ☐ Then slow commanded moves → then fast trajectories → RGB LED sync

Measurement	Predicted	Actual
Static trap with flat array	stable hover	______
Slow 3-D steering	smooth, no drops	______
Max reliable bead speed	≤ 8.75 m/s (literature ceiling)	______ m/s
POV shape (circle/line)	visible figure	______
Mid-air haptic point	felt on palm	______
Audible sound from array	recognizable tone	______

GATE S3 — pass: ☐ static-trap video ☐ POV-figure photo (long exposure) ☐ measured max speed ☐ bead-loss/re-trap behavior noted.

Stage 4 — V3 Museum Hardening (~$144 delta)

Safety stage, not polish. Until complete, machine runs attended only.

☐ Enclosure + security fasteners · levitator guard cage · warning signage (magnet/ultrasound) ☐ Access-panel interlock cuts coil power + levitator · hardware thermal cutoff independent of firmware ☐ E-STOP latching, one action kills coils + levitator · fused/switched IEC inlet, earth bonding, strain relief ☐ Software: attract/idle loop · bead-loss graceful recovery · 150 ms link watchdogs · daily restart

GATE S4 — the sign-off tests (each verified to reach safe state, each its own checkbox): ☐ Open access panel mid-show → safe state ☐ Trip thermal cutoff → safe state ☐ Hit E-STOP → safe state, latches until reset ☐ Pull Mega USB → coils drop ≤150 ms · ☐ Pull Nano USB → levitator idles ☐ Unattended soak test: ______ hours (spec: several minimum), zero interventions **Evidence:** video of each safe-state test + soak log. **Unlocks public deployment and Stage 5.**

Stage 5 — V4 Collaborative Exhibit (~$70 delta)

☐ One station wired (knob/slider→ADS1115, button debounced) → values streaming to host ☐ Calibration table per pot (min **__ / max _ / *dead-zone applied) ☐ One station → one feature confirmed (knob=height, slider=x, button=lock/reset) ☐ Stations duplicated:*** ___ total, each own feature + projected hue ☐ Collision handling behavior chosen (merge / repulsion) and demonstrated ☐ Fair-idle drift + no-visitors generative idle confirmed ☐ **Ensemble rehearsal: 2–3 people, tuned for responsiveness vs. calm** (the actual product test)

GATE S5 — pass: ☐ multi-person play video ☐ calibration table ☐ collision + idle demos. **The roadmap's destination: exhibit live.**

Standing Rules (shared with the Magnetic Matter Movers ladder)

1. No stage skips — each stage's reliability is the next one's foundation.
2. Deviation with a story is data; deviation ignored fails the gate.
3. Characterized values (tear-speed, feature count) become YOUR machine's spec sheet — record them like they matter, because every scene you author obeys them.
4. Bring each gate's evidence package back for review — that conversation is the troubleshooting session.
5. The three recurring hazards never expire: flyback diodes on every coil, ferrofluid stays sealed, ears away from 40 kHz.