Let us design a **world-class, hands-on STEM Lab curriculum** for VTU's pre-final & final year engineers that fits your constraint: **40 sessions × 1.5 hours = 60 hours**, 40 learners per lab, mixed disciplines, project every session.

Below you'll find:

1. a **complete 60-hour curriculum** arranged as 10 themed modules (4 sessions each)
2. a **session-by-session delivery plan** (what to teach + the project you'll build in the room)
3. a **bill of materials (BOM)** with quantities for a 40-seat lab (pair-work, 20 teams) and **current India price points** so you can raise a PO immediately

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Program goals (outcomes in 60 hours)

- **Job readiness:** demonstrable mini-portfolio (GitHub + short videos) across Robotics, IoT, Edge AI, CV, 3D printing, Cloud/DevOps, and Cyber/DFIR.
- **21C skills** embedded every session: problem framing → hypothesis → build → test → communicate (2-minute stand-ups each class).
- **Cross-discipline appeal:** each build has electrical/mechanical/software roles so Mech/EEE/EC/CS/IT/Bio-Med can contribute.

Teaching pattern per class (1.5h):

- 10 min: "why it matters" + safety
- 60 min: build & measure (pairs)
- 10 min: demo + reflect (one metric, one lesson)
- 10 min: checkpoint quiz / commit code / photo log

60-Hour Curriculum (10 modules × 4 sessions)

Each session lists: **Focus** · **Core Concepts** · **In-lab Project/Deliverable**

Module 1 — Lab Foundations & Rapid Prototyping (S1–S4)

S1. Lab safety & instruments · DMM/bench PSU/ESD, CAD→print basics · *Project:* test a sensor on breadboard; log readings.
S2. Microcontroller bring-up (Arduino/ESP32), digital/analog IO, PWM · *Project:* LED dimmer + button debounce.
S3. Serial + basic PCB intro (KiCad walkthrough) · *Project:* fabricate a tiny LED current-limiter PCB (virtual fab if needed).

S4. Mechanical fasteners & 3D design (parametric CAD) · *Project:* 3D-print a sensor mount (team's first custom part).

Module 2 — Sensors, Actuators & Control (S5–S8)

S5. Motors & drivers (DC, H-bridge, back-EMF) · *Project:* speed-controlled DC motor with L298N + tachometer.
S6. Servos & steppers · *Project:* servo pan-tilt that tracks a moving dot (mock).
S7. Closed-loop control (PID basics) · *Project:* balance a beam with PID (servo + IMU).
S8. Instrumentation & logging (I^2C/SPI; calibration) · *Project:* log IMU + temperature; plot & interpret trends.

Module 3 — IoT & Cloud (S9–S12)

S9. ESP32 networking (Wi-Fi/MQTT/REST) · *Project:* sensor → MQTT broker dashboard.
S10. Edge→Cloud pipelines (JSON, topics, qos) · *Project:* event rule (alert on threshold).
S11. Power & reliability (sleep modes, watchdogs) · *Project:* battery IoT node with 48-hour duty cycle sim.
S12. Device security primer (secrets, OTA) · *Project:* provision secure Wi-Fi creds; measured boot checklist.

Module 4 — Mobile Robotics (S13–S16)

S13. Robot chassis & kinematics (2WD differential) · *Project:* build & drive a calibrated 2WD bot.
S14. Line following & maze logic · *Project:* PID line follower with lap-time metric.
S15. Mapping & sensors (ultrasonic/IR) · *Project:* obstacle-avoid grid with state machine.
S16. Mech add-ons · *Project:* 3D-print a sensor bracket; improve ground clearance.

Module 5 — Computer Vision Foundations (S17–S20)

S17. Image basics (OpenCV, thresholds) · *Project:* shape/colour detector on webcam/RPi cam.
S18. Classical CV (edges, homography) · *Project:* fiducial tracking for robot docking.
S19. Data collection & labeling · *Project:* make a 100-image dataset (pairs) with good labeling SOP.
S20. Tiny classifiers (MobileNet/TFLite) · *Project:* run a simple classifier on Raspberry Pi.

Module 6 — ML/AI for Engineers (S21–S24)

S21. ML pipeline (split/fit/validate) · *Project:* predict motor RPM from PWM & load (regression).
S22. TinyML on MCU (quantization) · *Project:* gesture recognition on ESP32.
S23. Jetson bring-up (containers, CUDA, cameras) · *Project:* run YOLO-N/v8 on **Jetson Orin Nano**; FPS baseline.

S24. Edge optimization (INT8, batching) · *Project:* 2× speed improvement with profiling notes.

Module 7 — Edge + Cloud + DevOps (S25–S28)

S25. APIs & microservices (FastAPI) · *Project:* device → API → dashboard.
S26. CI/CD for firmware & models · *Project:* GitHub Actions builds + artifact versioning.
S27. Telemetry at scale (InfluxDB/Grafana) · *Project:* live lab dashboard.
S28. OTA & fleet mgmt · *Project:* staged rollout to 10 ESP32s (can simulate).

Module 8 — 3D Printing & DfAM (S29–S32)

S29. DfAM principles (tolerances, infill) · *Project:* print a motor mount; test fit.
S30. Materials & strength (PLA/PETG/TPU) · *Project:* bracket A/B test; report deflection.
S31. Design sprint (reverse-engineer a part) · *Project:* recreate + improve a coupler.
S32. Mech–elec integration · *Project:* printed enclosure with standoffs for MCU + sensors.

Module 9 — Cybersecurity & Digital Forensics for Engineers (S33–S36)

S33. Network fundamentals & traffic · *Project:* capture/interpret a device MQTT session (Wireshark).
S34. Threat modeling for robots/IoT · *Project:* STRIDE on your robot + mitigations backlog.
S35. Hardening & secure update · *Project:* sign firmware; verify at boot (demo).
S36. DFIR basics (logs, chain of custody) · *Project:* recover incident timeline from device logs.

Module 10 — Capstone & Showcase (S37–S40)

S37–S39. Capstone (3 sessions) · Teams pick one:

- **Robotics:** autonomous shelf inspector with CV.
- **Bio-med/IoT:** vital-signs node + cloud alerting + printed case.
- **Industrial:** predictive motor health with vibration sensor.
  Deliverables: 3-min demo video, repo, BOM, and a 1-page tech brief.
  S40. Expo & viva · Stakeholder demo day, rubric-based grading, career mapping.

Session-by-session delivery plan (what exactly happens each class)

To keep this readable, here's a **compact, actionable plan** you can hand your facilitators. (Each is 1.5h, follows the 10-60-10 structure.)

S1 instruments & safety · build a sensor readout
S2 GPIO/PWM · dimmer with button debounce
S3 UART/Serial & KiCad intro · tiny PCB (virtual)

S4 CAD basics · print a sensor mount
S5 DC motor theory · tachometered speed control
S6 servo/stepper · 2-axis pan-tilt
S7 PID · beam balancer
S8 sensor calibration · multi-sensor log
S9 MQTT · publish/subscribe node
S10 cloud rules · alerting pipeline
S11 low-power · duty-cycle node
S12 device security · secure Wi-Fi provisioning
S13 chassis build · calibrated driving
S14 line follow · PID tuning
S15 mapping · obstacle grid
S16 mech add-ons · printed bracket
S17 OpenCV · shape/colour detect
S18 homography · docking pose
S19 dataset SOP · 100-image set
S20 TFLite on Pi · tiny classifier
S21 ML pipeline · regression on RPM
S22 TinyML · micro-gesture
S23 Jetson bring-up · YOLO baseline (FPS)
S24 optimize · INT8/batching
S25 FastAPI · device API
S26 CI/CD · actions + artifacts
S27 telemetry · Grafana dashboard
S28 OTA · staged rollout
S29 DfAM · motor mount print
S30 materials · A/B strength test
S31 reverse-engineering sprint
S32 enclosure integration
S33 Wireshark lab · MQTT trace
S34 threat model · STRIDE board
S35 signed firmware demo
S36 DFIR mini-case
S37–S39 capstone build
S40 expo + viva

Assessment rubric (simple & fair): per session (10 pts): build passes test (4), code quality (2), measurement/graph (2), 60-sec verbal (2). Capstone (40 pts): problem framing (8), engineering rigor (12), demo quality (10), documentation (10).

Equipment & BOM (40 students, pairs = 20 teams)

Quantities below are **for the lab** (shared) unless marked "per team". Prices are **recent India list prices**—expect variation; use them to scope budgets and adjust with your vendor quotes.

Core compute & AI

- **Raspberry Pi 5 (8GB)** — **10 units** × **₹8,291** (incl. GST) from Robu (official distributor). (Robu)
- **Official 27W USB-C PSU for Pi 5** — **10 units** × **₹1,115**. (Robu)
- **NVIDIA Jetson Orin Nano Super Developer Kit (8GB)** — **4 units** × **₹21,540** (Tanna TechBiz; aligns with NVIDIA's **$249** pricing). (tannatechbiz.com, NVIDIA)

Microcontrollers & IoT (per team unless noted)

- **Arduino Uno R3 (with USB cable)** — **20 units** × **~₹478** (Robu) *(use official Arduino if you prefer; costs ~₹2,200 on Amazon)*. (Robu, Amazon India)
- **ESP32 DevKit** — **20 units** × **~₹670–₹849** (Flipkart examples). (Flipkart)
- **NodeMCU ESP8266** — **10 units (shared)** × **₹190–₹210** (KTRON / iFutureTech). (Ktron, iFuture Technology)
- **MicroSD 32GB (for Pi)** — **20 cards** (rotate across classes).
- **USB 1080p webcams** — **10 units**.

Sensors, motion & robotics (per team unless noted)

- **Sensor bundle** (DHT22, BMP280, HC-SR04, IR array, PIR, LDR, DS18B20, MPU-6050, RFID RC522) — **20 bundles**.
- **2WD robot chassis kit (with wheels)** — **20**.
- **DC geared motors (2 per team) + wheels** — **40 motors**.
- **L298N motor driver** — **20** (Robu/Quartz typical). (Robu, QuartzComponents)
- **Servos:** SG90 micro × **40**; **MG996R high-torque** × **20** (₹260–₹650 typical range). (Thingbits, Flipkart)
- **NEMA-17 stepper + A4988 + 12V/2A adapter** — **10 sets** (share across teams). Example prices ₹600–₹1,100 for motor. (Electronify India, Amazon India)
- **Breadboards + jumpers** — **20 kits**.

Fabrication & E-tools (shared)

- **3D Printers** (Creality Ender-3 series) — **2 units** × **~₹15,799** (Amazon India example). (Amazon India)
- **PLA filament 1 kg — 10 spools** × **~₹1,289** (3idea examples; economy options ₹699 exist). (3Idea)
- **Digital Multimeters (True-RMS) — 10 units**.
- **Bench power supplies (0–30V, ≥5A) — 4 units**.
- **Soldering stations (temp-controlled) — 6 units**; **hot-air rework — 2**; **fume extractors — 2**.
- **Logic analyzers (8-ch, 24 MHz) — 2**.
- **Oscilloscope (Rigol DS1054Z, 50 MHz, 4-ch) — 1 unit** (element14 **~₹37,415–₹40,745**). (Element14, Amazon India)
- **Hand tools** (pliers, cutters, wire-strippers, hex keys, calipers), fasteners assortment.
- **Safety** (ESD mats, 40 goggles, 2 fire extinguishers).

Lab operations (to run 40 students smoothly)

- **Seating:** 20 benches (pairs). Each bench gets: 1 laptop/desktop, Arduino + ESP32 kit, sensor bundle, small tool set; Pi/Jetson/stepper kits are **checkout/shared**.
- **Roles per pair:** driver (hardware) + scribe (code/notes). Rotate weekly.
- **Version control:** every team uses one GitHub repo; facilitators keep a "gold repo" of reference solutions.
- **Assessment cadence:** weekly score (10 pts), 3 mid-module quick vivas (S8, S16, S24), final capstone + viva (S40).
- **Safety SOPs:** 3D printer checklists, soldering PPE, Li-ion charging rules, and "no-internet firmware flashing" signs posted.

Why this works (and places grads globally)

- Every session ends with a **working artifact & metric** (FPS, lap-time, accuracy, weight, MTBF) → gives students the vocabulary employers trust.
- Threads the **whole stack** end-to-end: from a sensor → MCU → edge model on Pi/Jetson → cloud API → dashboard → printed enclosure → secured & observable.

- **Discipline-inclusive:** Mech/EEE own mounts, power, drivers; EC/CS own firmware, CV/ML; Bio-Med owns signal integrity and human factors; everyone learns to ship.

Notes on the price references

- **Raspberry Pi 5 (8GB)** listed around **₹8,291** at Robu (official distributor), and accessories/PSU pricing is published there too. (Robu)
- **Jetson Orin Nano Super Dev Kit (8GB)** shows **$249** officially and **₹21,540** at an Indian retailer (pre-order), which aligns with the USD price after VAT/imports. (NVIDIA, tannatechbiz.com)
- **Creality Ender-3** 3D printer is typically **₹15–17k** on Amazon India. (Amazon India)
- **Rigol DS1054Z** ranges **₹37–41k** from element14/Amazon India. (Element14, Amazon India)
- **ESP32/Arduino/NodeMCU** classroom-friendly pricing examples are listed to scope budgets quickly. (Flipkart, Robu, Ktron)