INTEGRATED ENGINEERING ACADEMY

Interactive Study Companion • Master Syllabus • Edition 1.0

Software and System Design Engineering
Electrical, Embedded and Automation Engineering
BMS, Industrial IoT, and Intelligent Facilities

48 modules | 8 phases | 36-month reference plan | 12 study hours/week

Personalized baseline: practical electrical maintenance; foundation mathematics; introductory programming. Training flagship: Hotel Engineering Asset Management System (AMS).

How to use this book

This document is the master syllabus, assessment handbook, and daily learning guide. The companion HTML study app presents exercises and local notes. Do not treat this handbook as proof of passing a module: advancement requires graded evidence and a mentor review.

Strict learning rule: complete modules in numeric order. Pass the module quiz at 80% or more, complete the practical deliverable, explain your reasoning, and receive mentor approval before moving on.

Daily gain rule: after each session, record one concept learned, one worked problem, one mistake corrected, and one artifact improved.

Weekly cadence: 4.5 h Python; 3 h mathematics; 2 h electrical; 1.5 h AMS/database; 1 h review. Rebalance as competence improves.

Safety: electrical and automation laboratory tasks start in simulation or safe extra-low-voltage circuits. Never change live hotel systems or safety interlocks for practice.

Module completion evidence

• Knowledge: 80% minimum on closed-book quiz; retest using a fresh variant after any failed attempt.

• Practical: working calculation, code, simulation or drawing; documented test cases and corrections.

• Explanation: independently explain WHY the design works; show a calculation or fault rationale.

• Mastery: no unlock merely for viewing a lesson or checking a box. Independent mentor verification is required for real progression.

Eight-phase program map

Phase 1: Engineering Foundations (3 months) — Energy calculator & safe simulated resistor circuit

Phase 2: Programming & Circuit Engineering (3 months) — CSV equipment register and temperature sensor scaling

Phase 3: Software Design & Industrial Control (4 months) — Work-order API & simulated duty/standby PLC

Phase 4: Software Architecture & Control Systems (5 months) — Multi-property AMS design & HVAC PID simulation

Phase 5: Infrastructure, DevOps & Embedded Systems (5 months) — Deployed nonproduction AMS & IoT sensing gateway

Phase 6: Distributed & Intelligent Systems (5 months) — Offline synchronization prototype & energy analytics

Phase 7: Advanced Engineering Integration (5 months) — Simulated BMS/AMS integration with OT risk review

Phase 8: Professional Engineering Capstone (6 months) — Integrated professional portfolio & capstone defense

PHASE 1: Engineering Foundations

Capstone: Energy calculator & safe simulated resistor circuit

Module 01 — Engineering Mathematics I

Scope: Algebra; equations; formulas; graphs; functions; trigonometry; units and dimensional analysis.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 02 — Computer Science Fundamentals

Scope: CPU, memory, storage, binary representation, logic, processes, operating systems and files.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 03 — Python Programming I

Scope: Variables, types, conditions, loops, functions, collections, files, exceptions and debugging.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 04 — Electrical Engineering I

Scope: Ohm and Kirchhoff laws; voltage, current, power; AC/DC; safe isolation; circuit calculations.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 05 — Engineering Tools

Scope: VS Code; terminal; folders; Linux basics; Git; GitHub; debugging workflows.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 06 — Engineering Drawings & Documentation

Scope: Schematic symbols; wiring and single-line diagrams; AutoCAD basics; technical reporting.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

PHASE 2: Programming & Circuit Engineering

Capstone: CSV equipment register and temperature sensor scaling

Module 07 — Python Programming II & OOP

Scope: Classes and objects; composition; inheritance; modules; interfaces; readable code.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 08 — Data Structures & Algorithms

Scope: Lists, queues, stacks, maps, searching, sorting, recursion, time complexity.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 09 — Database Engineering I

Scope: Tables, primary and foreign keys, normalization, SELECT, JOIN, indexes, transactions.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 10 — Electronics Fundamentals

Scope: Diodes, transistors, MOSFETs, relays, logic gates, power supplies, basic circuit safety.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 11 — Instrumentation Fundamentals

Scope: Temperature, pressure, flow sensors; 4-20 mA; 0-10 V; scaling; accuracy and calibration.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 12 — Testing & Version Control

Scope: Git branching; assertions; unit tests; debugging; code review; simple CI.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

PHASE 3: Software Design & Industrial Control

Capstone: Work-order API & simulated duty/standby PLC

Module 13 — Requirements Engineering & UML

Scope: Stakeholders; user stories; functional/nonfunctional requirements; UML; traceability.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 14 — Low-Level Software Design

Scope: Encapsulation; SOLID; separation of concerns; patterns; refactoring.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 15 — Web Applications & APIs

Scope: HTTP; JSON; REST; FastAPI; authentication basics; validation and tests.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 16 — Industrial Electrical Controls

Scope: Contactors; overloads; interlocks; motor starters; controls; panel diagrams.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 17 — PLC Programming I

Scope: PLC scan cycle; I/O; ladder logic; timers; counters; state transitions.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 18 — Motors & VFD Fundamentals

Scope: Three-phase motors; ratings; torque; speed; VFD basics and protection.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

PHASE 4: Software Architecture & Control Systems

Capstone: Multi-property AMS design & HVAC PID simulation

Module 19 — System Design & Architecture

Scope: Modular monolith; client-server; architecture boundaries; data flow; trade-offs.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 20 — Advanced Database & Storage Design

Scope: PostgreSQL; joins; query plans; indexes; transactions; backups and migrations.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 21 — Networking & Industrial Protocols

Scope: TCP/IP; routing; Ethernet; serial protocols; Modbus TCP/RTU; BACnet introduction.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 22 — Control Systems Engineering

Scope: Feedback; transfer functions; PID; stability; response time; simulation.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 23 — BMS/DDC Engineering

Scope: DDC controllers; points schedules; sequences; trends; alarms; BMS commissioning.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 24 — Applied System Architecture

Scope: Caching; message queues; load balancing; capacity; performance validation.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

PHASE 5: Infrastructure, DevOps & Embedded Systems

Capstone: Deployed nonproduction AMS & IoT sensing gateway

Module 25 — Operating Systems & Servers

Scope: Linux administration; logs; users; permissions; shells; operating processes.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 26 — Cloud & DevOps

Scope: Docker; CI/CD; cloud compute; deployment; infrastructure as code.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 27 — Embedded Programming

Scope: C programming; MCU architecture; GPIO; memory; interrupts; timers and PWM.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 28 — Microcontrollers & Interfaces

Scope: ESP32/STM32; I2C; SPI; UART; ADC; sensor interfaces; watchdogs.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 29 — IoT Communication & Telemetry

Scope: MQTT; gateways; device identity; buffering; edge telemetry; time-series data.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 30 — Application & Operational Security

Scope: Passwords; authorization; secrets; TLS; backups; security-by-design.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

PHASE 6: Distributed & Intelligent Systems

Capstone: Offline synchronization prototype & energy analytics

Module 31 — Distributed Systems

Scope: Concurrency; replicas; consistency; availability; fault tolerance.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 32 — Offline-First Engineering

Scope: Local storage; offline sync; conflict resolution; idempotency; reconciliation.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 33 — Message Queues & Event Streaming

Scope: Brokers; asynchronous jobs; retries; dead letters; event ordering.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 34 — Data Analytics & Engineering

Scope: Python data analytics; statistics; time series; visualizations; anomalies.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 35 — Building Energy & Operational Analytics

Scope: Energy baselines; kWh; power factor; demand; efficiency; performance indicators.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 36 — Digital Twin Fundamentals

Scope: Digital twin definition; asset models; telemetry links; simulation limits.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

PHASE 7: Advanced Engineering Integration

Capstone: Simulated BMS/AMS integration with OT risk review

Module 37 — Advanced Software Architecture

Scope: Microservices tradeoffs; multitenancy; multiregion basics; cost controls.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 38 — System Reliability Engineering

Scope: Observability; SLI/SLO; alerting; incidents; performance; disaster recovery.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 39 — Advanced Industrial Automation

Scope: PLC state machines; sequencing; redundancy; industrial communication.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 40 — Industrial Cybersecurity

Scope: IT/OT segmentation; ISA/IEC 62443 concepts; threat modeling.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 41 — Systems Integration

Scope: BACnet, Modbus and MQTT mapping; integration gateways; asset tagging.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 42 — Design Verification & Commissioning

Scope: FAT; SAT; validation; change control; acceptance criteria; as-built documents.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

PHASE 8: Professional Engineering Capstone

Capstone: Integrated professional portfolio & capstone defense

Module 43 — Advanced System Design Practice

Scope: Architecture case studies; decision records; reviews and technical interviews.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 44 — Engineering Project Management

Scope: Budgeting; scheduling; procurement; risk; quality and stakeholder communication.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 45 — Professional Technical Documentation

Scope: SRS; SOPs; P&ID interpretation; technical manuals; drawing registers.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 46 — Product Engineering & Commercialization

Scope: Licensing; support; product packaging; pricing; commercial risk.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 47 — Integrated Capstone Development

Scope: Integrated AMS + simulated BMS gateway; safety; deployment rehearsals.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

Module 48 — Portfolio & Professional Assessment

Scope: Portfolio; capstone defense; final demonstrations; professional development.

Practice: define a facility-engineering example; construct a small solution or simulation; test edge cases; write a one-page report with assumptions and results.

Gate: quiz >=80%, checked practical artifact, written explanation and explicit mentor approval.

First 14 days: foundation sprint

Day 01 — Orientation and unit notation: Compute W to kW for three equipment labels.

Day 02 — Algebra variables: Solve 3x+7=22, then invent a similar equation.

Day 03 — Formula rearrangement: Rearrange P=VI for V and I.

Day 04 — Engineering energy: Compute 30-day kWh for a motor.

Day 05 — Binary and Boolean logic: Draw an AND and OR decision table.

Day 06 — Review and corrections: Explain one error in writing and repeat the calculation.

Day 07 — Mastery checkpoint: Closed-book quiz, project walkthrough, mentor signoff.

Day 08 — Python variables: Predict and run a 3-line calculation.

Day 09 — Data types and arithmetic: Identify integer, float and string examples.

Day 10 — Python conditional logic: Build temperature threshold output.

Day 11 — Boolean operators: Implement NORMAL/WARNING/CRITICAL logic.

Day 12 — Python loops: Iterate through five sensor values.

Day 13 — Debugging: Find and fix three broken-code examples.

Day 14 — Programming checkpoint: Demo simulator and explain logic without assistance.

Daily lesson template

Recall: 5 minutes — reproduce yesterday’s rule from memory.

Visual: 10–20 minutes — diagram or interactive simulation.

Reason: 20 minutes — predict outcomes before calculation.

Build: 30–50 minutes — solve a new practical challenge.

Reflect: 10 minutes — note one misconception, one insight and one next action.

First lesson example: equipment energy

Power (kW) = power (W)/1000. Energy (kWh) = power (kW) × operating hours. For 750 W operating four hours: 0.75 kW × 4 h = 3 kWh. This assumes actual input power remains constant.

Practice: 1,500 W for 8 h on each of 30 days gives 360 kWh. Explain why actual VFD-controlled loads can differ from constant-power estimates.

Mentor discussion prompts

• What input assumptions could make my calculated answer incorrect?

• Show me why this formula works instead of just giving the result.

• Give me an increasingly difficult version without providing the answer.

• Review my code for logic mistakes but do not rewrite it for me.

Recommended companion sites

Brilliant (visual logic and mathematics) — https://brilliant.org/

Khan Academy (foundational mathematics mastery) — https://www.khanacademy.org/

Exercism Python (code exercises) — https://exercism.org/tracks/python

Tinkercad Circuits (introductory electronic simulation) — https://www.tinkercad.com/circuits

Wokwi (embedded simulation) — https://wokwi.com/

Obsidian (independent linked notes) — https://obsidian.md/