Bachelor of Science in Mechanical Engineering (4 Years, 240 ECTS)

> A comprehensive, practice-heavy curriculum spanning mechanics, materials, thermofluids, design & manufacturing, dynamics & control, and sustainability. Structured across 8 semesters (30 ECTS each) with integrated labs, projects, and professional skills.

Program Overview

- **Award:** B.Sc. in Mechanical Engineering
- **Duration:** 8 Semesters (4 academic years)
- **Total Credits:** 240 ECTS
- **Delivery:** Lectures (L), Tutorials (T), Laboratories (P), Studio/Project (S)
- **Workload:** ≈ 25–30 hours/ECTS
- **Pillars:** Solid mechanics, dynamics & vibration, thermodynamics, heat transfer, fluid mechanics, design & CAD/CAE, manufacturing & materials, mechatronics & control, energy systems, sustainability & ethics.

Graduate Learning Outcomes

Graduates will be able to: 1. **Model** mechanical systems using first principles (Newton/Euler, conservation laws) and modern CAE tools.
2. **Design** components and assemblies to meet functional, safety, and cost targets using DfX principles.
3. **Analyze** structural, thermal, and fluid phenomena via closed-form, numerical (FEM/CFD), and experimental methods.
4. **Manufacture & validate** prototypes using conventional and digital fabrication; interpret GD&T and inspection data.
5. **Control** dynamic systems and integrate sensors/actuators with embedded control for mechatronic products.
6. **Evaluate** energy systems, life-cycle impacts, and sustainability metrics with appropriate standards.
7. **Communicate** designs, risks, and decisions ethically and professionally; work effectively in teams.
8. **Learn** independently and adapt to evolving technologies and regulations.

Curriculum Map (By Semester)

Includes **ECTS**, **L-T-P-S**, **Prerequisites (Pre)**, **Assessment**, **Tools**, and **Detailed Description**.

Semester 1 (30 ECTS)

1. **ME101 Engineering Mathematics I (Calculus & Vectors)** (6 ECTS, 3-1-0-0)
   Assessment: PSets 35%, Midterm 25%, Final 40%

Topics: Limits, derivatives, integrals, vector algebra, partial derivatives, multiple integrals.
Applications: Kinematics, hydrostatics, centroid/area.

2. **ME102 Engineering Physics (Mechanics)** (6 ECTS, 3-1-1-0)
   Topics: Motion, forces, work-energy, impulse-momentum, rigid body basics.
   Labs: Atwood machine, ballistic pendulum, friction & energy losses.

3. **ME103 Introduction to Mechanical Design & CAD** (6 ECTS, 2-0-2-1)
   Tools: SolidWorks/Inventor, Onshape, GD&T basics
   Project: Parametric modeling of a gearbox assembly and drawing package.
   Assessment: Labs 35%, Design Project 25%, Quizzes 15%, Final 25%.

4. **ME104 Programming for Engineers (MATLAB/Python)** (6 ECTS, 2-1-2-0)
   Topics: Numerical methods intro, data processing, plotting, scripts & functions, version control.
   Labs: Root finding, interpolation, ODE solver mini-projects.

5. **ME105 Communication, Ethics & Safety I** (6 ECTS, 2-1-0-1)
   Focus: Technical writing, presentations, lab safety, ethics cases (ASME code), inclusive design.

Semester 2 (30 ECTS)

1. **ME106 Engineering Mathematics II (DEs & Linear Algebra)** (6 ECTS, 3-1-0-0)
   Pre: ME101
   Topics: ODEs, Laplace, linear systems, eigenvalues, Fourier series.
   Applications: Vibrations, circuits analogies, thermal transients.

2. **ME107 Materials Science & Engineering** (6 ECTS, 3-0-2-0)
   Topics: Atomic structure, phases, mechanical behavior, failure (fatigue/creep), polymers/composites, corrosion.
   Labs: Tension tests, hardness, microscopy, heat treatment.

3. **ME108 Statics** (6 ECTS, 3-1-0-0)
   Topics: Force systems, equilibrium, structures, trusses/frames, friction, centroids, MoI.
   Tutorials: Method of joints, shear/moment diagrams prelude.

4. **ME109 Engineering Graphics & GD&T** (6 ECTS, 2-0-2-1)
   Topics: Dimensioning, tolerancing, datums, fits, surface finish; drawing standards.
   Project: Drawing package with full GD&T for a bracket assembly.

5. **ME110 Workshop Practice & Fabrication** (6 ECTS, 1-0-3-1)
   Topics: Machining (turn/mill), CNC intro, additive, welding, metrology, safety/5S.
   Labs: Build a clamp assembly; CMM inspection; process plan write-up.

Semester 3 (30 ECTS)

1. **ME201 Dynamics** (6 ECTS, 3-1-0-0)
   Pre: ME108
   Topics: Kinematics of particles/rigid bodies, energy/momentum methods, impact, planar motion.
   Assessment: PSets 30%, Midterm 25%, Final 45%.

2. **ME202 Mechanics of Materials I** (6 ECTS, 3-0-2-0)
   Topics: Axial, torsion, bending, shear, deflection, stress/strain transformations, failure criteria.
   Labs: Strain gage bridge, beam bending, torsion of shafts.

3. **ME203 Thermodynamics I** (6 ECTS, 3-1-0-0)
   Topics: Properties, first/second law, entropy, power/refrigeration cycles.
   Tutorials: Steam tables, psychrometrics intro.

4. **ME204 Numerical Methods for ME** (6 ECTS, 2-1-2-0)
   Tools: MATLAB/Python
   Topics: Linear systems, interpolation, numerical differentiation/integration, ODE IVP/BVP.
   Project: Solve a heat fin ODE/BVP + verification.

5. **ME205 Communication, Ethics & Safety II** (6 ECTS, 2-1-0-1)
   Focus: Risk registers, sustainability reporting, standards overview (ISO, ASME Y14.5, OSHA/CE).

Semester 4 (30 ECTS)

1. **ME206 Fluid Mechanics** (6 ECTS, 3-0-2-0)
   Topics: Fluid statics, conservation laws, viscous flow, internal/external flows, turbomachinery intro.
   Labs: Venturi meter, boundary layer, pump curves.

2. **ME207 Heat Transfer** (6 ECTS, 3-0-2-0)
   Topics: Conduction, convection, radiation, heat exchangers, fins, transient analysis.
   Labs: Transient conduction rig, HX performance mapping.

3. **ME208 Machine Design I (Elements)** (6 ECTS, 3-0-2-0)
   Pre: ME202
   Topics: Stress/deflection in design, static/fatigue failure, shafts, keys, bearings, springs, fasteners.
   Project: Design of a belt-driven transmission—sizing & drawings.

4. **ME209 Measurement & Instrumentation** (6 ECTS, 2-0-2-1)
   Topics: Sensors (temp/strain/pressure/flow), signal conditioning, DAQ, uncertainty, calibration.
   Labs: NI/DAQ or microcontroller-based measurements; uncertainty propagation.

5. **ME2E1 Technical Elective I** (6 ECTS)

Semester 5 (30 ECTS)

1. **ME301 Finite Element Analysis** (6 ECTS, 2-0-3-0)
   Tools: ANSYS/Abaqus, CalculiX
   Topics: Discretization, element types, meshing, convergence, verification & validation, contact, nonlinearity intro.
   Project: Structural analysis of a bracket; report with V&V.

2. **ME302 Control Systems & Mechatronics I** (6 ECTS, 2-0-3-0)
   Pre: ME201, ME209, ME104
   Topics: Modeling (free-body, energy methods), transfer functions, block diagrams, time/frequency response, PID tuning.
   Labs: DC motor position control; Arduino/STM32; sensor fusion basics.

3. **ME303 Manufacturing Processes & Systems** (6 ECTS, 3-0-2-0)
   Topics: Casting, forming, machining, joining, additive, metrology, process planning, lean/DFM/DFA, cost estimation.
   Labs: CNC toolpaths (CAM), additive lattice sample.

4. **ME304 Thermodynamics II & Power Cycles** (6 ECTS, 3-1-0-0)
   Topics: Gas/vapor cycles, combustion basics, exergy, compressible flow, propulsion intro.
   Case studies: Combined cycles, CHP, heat pumps.

5. **ME3E2 Technical Elective II** (6 ECTS)

Semester 6 (30 ECTS)

1. **ME305 Machine Design II (Systems)** (6 ECTS, 2-0-3-0)
   Pre: ME208
   Topics: Gears (spur/helical), gear trains, clutches/brakes, cams, transmissions, reliability, tolerancing for assembly.
   Project: Gearbox design with AGMA checks & GD&T.

2. **ME306 Fluid Machinery & HVAC** (6 ECTS, 3-0-2-0)
   Topics: Pumps, turbines, compressors, fans; psychrometrics; HVAC components; building energy modeling intro.
   Labs: Fan performance map; HVAC coil experiment.

3. **ME307 Vibration & Structural Dynamics** (6 ECTS, 3-0-2-0)
   Topics: 1-DOF/MDOF systems, modal analysis, damping, frequency response, isolation, rotating machinery.
   Labs: Modal testing with impact hammer/accelerometers.

4. **ME3E3 Technical Elective III** (6 ECTS)

5. **ME398 Summer Internship (0 ECTS, required)**
   Deliverables: Learning plan, supervisor evaluation, reflective report.

Semester 7 (30 ECTS)

1. **ME401 Computational Fluid Dynamics** (6 ECTS, 2-0-3-0)
   Pre: ME206, ME207, ME204
   Topics: Governing equations, discretization (FDM/FVM), turbulence models RANS/LES (overview), boundary conditions, verification & validation.
   Project: External aero or internal duct flow simulation and wind-tunnel/bench correlation.

2. **ME402 Control Systems & Mechatronics II (Embedded/Real-Time)** (6 ECTS, 2-0-3-0)
   Topics: State-space, observers (Luenberger/Kalman intro), digital control, discretization, real-time scheduling, communication buses (CAN, SPI, I2C).
   Project: Self-balancing inverted pendulum or quadrotor simulation→hardware.

3. **ME403 Product Development & Systems Engineering** (6 ECTS, 2-1-2-0)
   Topics: Requirements, QFD, DFMEA/FTA, reliability, cost/BoM, regulatory (CE/ISO), lifecycle, sustainability & circularity.
   Studio: Concept to PRD and verification plan.

4. **ME4E4 Technical Elective IV** (6 ECTS)

5. **ME490 Capstone I (Proposal & Architecture)** (6 ECTS, 0-1-0-4)
   Activities: Problem framing, stakeholder/market analysis, specs, risk & ethics review, architecture & test plan.

Semester 8 (30 ECTS)

1. **ME491 Capstone II (Implementation & Validation)** (12 ECTS, 0-0-2-6)
   Deliverables: Prototype, test results, design history file, cost & manufacturability analysis, poster + public demo, reproducible repo.
   Examples: Solar-assisted heat pump; autonomous inspection robot; high-efficiency UAV propeller; low-noise HVAC fan; human-powered vehicle.

2. **ME404 Renewable & Sustainable Energy Systems** (6 ECTS, 3-0-2-0)
   Topics: Wind, solar thermal/PV, bioenergy, heat pumps, storage, LCA, techno-economic analysis.
   Labs: Solar collector/heat pump bench; LCA software exercise.

3. **ME4E5 Technical Elective V** (6 ECTS)

4. **ME405 Engineering Management & Entrepreneurship** (6 ECTS, 2-1-2-0)
   Topics: Project planning, costing, supply chain, IP, standards & certification, business models, design

for sustainability.
Studio: Go-to-market plan for capstone or new product.

Technical Elective Tracks (Sample Offerings)

Choose at least **5 electives**; at least **2** must be lab/design focused.

Track A — Aerospace & Propulsion

- **ME451 Aerodynamics & Aircraft Performance** (6 ECTS) — Airfoils, wings, drag, performance, stability basics; wind-tunnel lab.
- **ME452 Gas Turbines & Jet Propulsion** (6 ECTS) — Brayton cycle, components, compressible flow, combustion.
- **ME453 Space Systems Fundamentals** (6 ECTS) — Orbital mechanics intro, structures/thermal, propulsion overview.

Track B — Automotive & Mobility

- **ME461 Automotive Powertrains & EVs** (6 ECTS) — ICE/HEV/BEV architectures, e-motors, batteries, thermal mgmt, charging.
- **ME462 Vehicle Dynamics** (6 ECTS) — Ride/handling, tire models, suspension/steering, braking, simulation lab.
- **ME463 Thermal Management of Vehicles** (6 ECTS) — Radiators, heat pumps, cabin HVAC, battery cooling.

Track C — Robotics & Mechatronics

- **ME471 Robotics (Kinematics & Control)** (6 ECTS) — DH parameters, FK/IK, Jacobians, path planning, control; ROS lab.
- **ME472 Sensors & Embedded Systems for Robotics** (6 ECTS) — Perception sensors, sensor fusion, real-time middleware, safety.
- **ME473 Industrial Automation & PLCs** (6 ECTS) — PLC programming, SCADA, pneumatics/hydraulics, safety circuits.

Track D — Advanced Manufacturing & Materials

- **ME481 Additive Manufacturing** (6 ECTS) — Processes, design for AM, topology optimization, post-processing, materials.
- **ME482 Composite Structures** (6 ECTS) — Lamina/laminate theory, failure, manufacturing methods, NDT.
- **ME483 Tribology & Surface Engineering** (6 ECTS) — Friction/wear/lubrication, coatings, testing.

Track E — Energy, HVAC & Sustainability

- **ME491* Building Energy Modeling** (6 ECTS) — Loads, systems, controls, standards, simulation labs.
- **ME492 Thermal Systems Design** (6 ECTS) — HX networks, optimization, pinch analysis, TEA.
- **ME493 Power Plant Engineering** (6 ECTS) — Steam, gas, combined cycles, emissions, CCS.

Note: ME491 here denotes an elective code; institutions may renumber to avoid collision with Capstone.

Laboratories & Facilities

- **Thermofluids lab:** wind tunnel, flow benches, HX rigs, pumps & fans, PIV (demo).
- **Materials & manufacturing:** UTM, hardness testers, microscopes, furnaces, CNC mills/lathes, 3D printers (FDM/SLA/SLS), welding.
- **Dynamics & vibration:** Shaker table, impact hammer, accelerometers, DAQ.
- **Mechatronics:** Microcontrollers (STM32/Arduino), motor drives, sensors, PLCs, ROS robots.
- **CAE:** Workstations with CAD/CAE (SolidWorks/Inventor, ANSYS/Abaqus/CFX/Fluent), MATLAB/Python, version control.

Tools & Methodologies

- **CAD/CAM:** SolidWorks/Inventor, NX/Fusion; CAM (HSM/EdgeCAM).
- **CAE:** FEA (ANSYS/Abaqus/CalculiX), CFD (Fluent/CFX/OpenFOAM), Multibody (ADAMS), Optimization (DesignXplorer).
- **Data & Control:** MATLAB/Simulink, Python (NumPy/SciPy), LabVIEW.
- **Quality & Metrology:** GD&T, CMM, SPC, MSA.
- **Product development:** DFx, QFD, FMEA/FTA, stage-gate, PLM basics.
- **Safety & Sustainability:** Risk assessment, LCA (OpenLCA/SimaPro), circularity, standards mapping.

Capstone Design Sequence (ME490/ME491 Details)

- **Phase 1 — Architecture & Planning (ME490):** Requirements, system architecture, BoM/costing, safety & compliance planning (pressure vessels, machinery directive), V&V plan, ethics & sustainability analysis.
- **Gate A:** Design review & risk sign-off.
- **Phase 2 — Build, Test & Validate (ME491):** Prototype fabrication, instrumentation, test execution, design iteration, manufacturing plan, maintainability & reliability analysis, user/safety documentation.
- **Gate B:** Public demo, poster/paper, repository & documentation handover, post-mortem.

Professional Practice & Experiential Learning

- **Internship (after Sem 6):** 6–10 weeks in industry/research with reflective report.
- **Co-op (optional):** 20–24 weeks spanning Sem 7–8.
- **Industry seminars:** Monthly talks on aerospace, automotive, energy, and manufacturing innovations.

Assessment & QA

- **Rubrics:** Emphasize correctness, modeling rigor, validation evidence, documentation, safety, sustainability.
- **Authentic assessment:** Open-ended labs, design critiques, shop builds, oral exams.
- **Integrity:** Plagiarism tools + viva for major submissions.
- **Program review:** Annual external advisory board and alumni feedback.

Suggested Texts & References

- **Mechanics:** Vector Mechanics for Engineers (Beer & Johnston) / Engineering Mechanics (Hibbeler)
- **Materials:** Materials Science & Engineering (Callister)
- **Thermo/Heat:** Thermodynamics (Çengel & Boles); Heat Transfer (Incropera)
- **Fluids:** Fluid Mechanics (Fox/McDonald) or White
- **Design:** Shigley's Mechanical Engineering Design
- **Controls:** Feedback Systems (Åström & Murray) / Modern Control Engineering (Ogata)
- **FEA/CFD:** Cook et al. (FEA); Versteeg & Malalasekera (CFD)

Accreditation Mapping (Template)

- **Math & Science:** $\geq$ 60 ECTS across calculus, DEs, physics, materials, thermofluids.
- **Engineering Topics:** $\geq$ 120 ECTS (design-heavy $\geq$ 60 ECTS, including capstone).
- **Professional Skills:** $\geq$ 12 ECTS communication/ethics/safety with integrated checkpoints.
- **Experiential:** Internship + capstone; external review.

Customization & Localization Notes

- Convert ECTS to local credit units as needed.
- Align safety & compliance with regional standards (e.g., PED/ASME, CE/ISO).
- Offer language/local policy modules as electives.
- Provide accommodations and inclusive pedagogy strategies.

Appendix A — Weekly Syllabi Snapshots (Examples)

ME208 Machine Design I (Weeks 1–14):
- W1: Stress/strain review; W2: Failure theories; W3: Shafts/keys; W4: Fasteners; W5: Springs; W6: Bearings; W7: Welded joints; W8: Fatigue; W9: Reliability; W10: Safety factors; W11: Materials selection; W12: Tolerancing; W13: Project clinic; W14: Review.
Assessments: Labs 25%, Midterm 20%, Final 35%, Project 20%.

ME206 Fluid Mechanics (Weeks 1–14):
- W1: Properties/statics; W2: Dimensional analysis; W3: Control volumes; W4: Bernoulli; W5: Viscous flow; W6: Pipe networks; W7: External flows; W8: Boundary layers; W9: Drag/lift; W10: Pumps; W11: Compressible intro; W12: Turbomachinery; W13: Lab clinic; W14: Review.
Assessments: Labs 30%, Midterm 20%, Final 35%, Project 15%.

ME402 Mechatronics II (Weeks 1–14):
- W1: State-space; W2: Observers; W3: Digital control; W4: Real-time; W5: Buses; W6: Sensor fusion; W7: Safety; W8: HIL testing; W9: Optimization; W10: Embedded deployment; W11: Faults; W12: Documentation; W13: Demo prep; W14: Demos.

Appendix B — Example Capstone Briefs

- **Solar-Assisted Heat Pump for Residential Heating:** Performance modeling, refrigerant selection, HX design, control, LCA, compliance.
- **Autonomous Warehouse Robot:** Chassis & drivetrain, sensing & control, safety interlocks, fleet coordination basics, manufacturability.
- **Lightweight Composite Bicycle Frame:** Laminate design, topology optimization, layup & curing, structural testing, fatigue analysis.

Appendix C — Rubrics (Abbreviated)

- **Design Project:** Requirements (15), Modeling/analysis (20), Implementation/prototype (25), V&V evidence (20), Documentation (10), Safety & sustainability (10).
- **Lab Report:** Preparation (10), Method (20), Data & analysis (30), Discussion (20), Presentation (10), Safety/ethics (10).

This syllabus is a detailed template. Adjust prerequisites, contact hours, and facilities for local constraints while maintaining learning outcomes and design depth.