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Advance Skill Development / Open Elective-I — Complete Syllabus

BTEUP Diploma in Mechanical Engineering • 3rd Semester • Session 2026–27
Subject 3.7 (Qualifying) • 2 Credits • Open Elective-I: Internal 50 Marks

Qualifying subject — read this first: you must PASS this subject, but its marks are **not** added to your awarded division or total marks. There are two routes to the same 2 credits: take one taught Open Elective-I subject (2 lectures a week, 50 internal marks, no external exam), **or** earn an Advance Skill Development certificate (minimum 20 hours of skill certification from a recognised national or international agency or institute). Tata Tech-based Open Elective-I subjects are offered preferably at the centres established by Tata Tech.

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Examination Scheme

Code	Paper	Type	L – P	Credits	Internal	External	Total
3.7	Advance Skill Development	Qualifying	—	2	Certificate (min. 20 hrs)	—	—
3.7	Open Elective-I	Qualifying	2 – 0	2	50	—	50†

What This Subject Aims To Do

To let every student add one extra, industry-relevant skill beyond the core mechanical subjects — either by studying one elective subject from the official basket, or by completing a certified skill course of at least 20 hours with a recognised agency. The elective basket mixes AICTE theory subjects (material handling, energy audit, robotics) with hands-on Tata Tech

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courses (welding and painting on simulators, IoT, product verification and analysis) and certified online courses (NPTEL, SWAYAM, C-DAC, ISRO and others).

Route 1 — Open Elective-I (taught subject)

Choose ONE subject from the basket below. Each taught option carries 2 credits and is assessed internally for 50 marks, with no external examination. The three AICTE options are theory subjects (2 lectures a week); the three Tata Tech options are practical, hands-on courses.

Option 1 — Material Handling Systems (AICTE) · 3.7.1 · L 2 · 2 credits

Unit I — Introduction: main types of material handling equipment and their applications; types of load to be handled; types of movements; methods of stacking, loading and unloading systems; principles of material handling systems; modern trends. **Unit II — Hoisting machinery & equipment:** construction, working and maintenance of hoists (lever operated, portable hand chain, differential, worm geared, spur geared, electric and pneumatic hoists, jumper); cranes (rotary, trackless, mobile, bridge, cable, floating, and cranes travelling on guide rails); elevating equipment (stackers, industrial lifts, freight elevators, passenger lifts, mast type elevators, vertical skip hoist elevators). **Unit III — Conveying machinery:** traction type conveyors (belt, chain, bucket elevators, escalators); traction-less conveyors (gravity, vibrating and oscillating, screw, pneumatic and hydraulic conveyors, hoppers, gates and feeders); surface transportation equipment (hand operated trucks, powered trucks, tractors, automatic guided vehicle, industrial trailers); cross handling equipment (winches, capstans, turntables, transfer tables, monorail conveyors). **Unit IV — Components:** flexible hoisting appliances (welded load chains, roller chains, hemp ropes, steel wire ropes, fastening methods, eyebolts, lifting tackles, lifting and rigging practices); load handling attachments (hooks — forged, triangular eye; crane grab; electric lifting magnet, vacuum lifter; grabbing attachments for loose materials; attachments for liquids, molten metals); arresting gear and brakes (electromagnetic shoe brakes, thruster operated shoe brakes, control brakes). **Unit V — Mechanisms & selection:** steady state motion; starting and stopping of hoisting, lifting, travelling, slewing, and rope & chain operated cross-traverse mechanisms; factors affecting the choice of equipment (type of loads, hourly capacity, direction and length of travel, stocking methods, production process, load conditions, economics).

Books: Material Handling (Principles & Practice) — Allegri T.H., CBS; Plant Layout & Materials Handling — Apple J.M., Wiley; Material Handling Equipment — N. Rundenko, Peace, Moscow; Material Handling Equipment — M.P. Alexandrov, MIR, Moscow; Material Handling Equipment — Y.I. Oberman, MIR, Moscow.

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Option 2 — Energy Conservation & Audit (AICTE) · 3.7.2 · L 2 · 2 credits

Unit I — Introduction: general energy problem; sector-wise energy consumption; demand-supply gap; scope for energy conservation and its benefits; energy efficiency principles — maximum energy efficiency, maximum cost effectiveness; mandatory provisions of the EC Act; features of the EC Act — standards and labelling, designated consumers, Energy Conservation Building Codes (ECBC). **Unit II — Conservation approaches in industries:** methods and techniques of energy conservation in ventilation and air conditioners, compressors, pumps, fans and blowers — area sealing, insulating heating/cooling fluid pipes, automatic door closing, air curtain, thermostat/ control; energy conservation in electric furnaces, ovens and boilers. **Unit III — Conservation options:** new equipment, technology, staffing, training; calculation and costing of an energy conservation project; depreciation cost, sinking fund method; cost evaluation by return on investment (ROI) and payback method. **Unit IV — Performance improvement of existing power plant:** cogeneration, small hydro, DG set; demand side management; load response programme; types of tariff and restructuring of electric tariff; technical measures to optimise T&D losses. **Unit V — Energy audit:** energy audit and its benefits; energy flow diagram; preliminary and detailed energy audit; methodology — Phase I pre-audit, Phase II audit, Phase III post-audit; energy audit report; electrical measuring instruments — power analyzer.

Books: Electric Energy Generation, Utilisation and Conservation — Sivaganaraju S., Pearson, 2012; Project Management — Prasanna Chandra, Tata McGraw Hill; Energy Conservation in Buildings — O.P. Jakhar, Khanna; Financial Management — Prasanna Chandra, Tata McGraw Hill; Energy Management Handbook — Prasanna Chandra, Tata McGraw Hill; Energy Technology — O.P. Gupta, Khanna, 2018.

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Option 3 — Industrial Robotics & Automation (AICTE) · 3.7.4 · L 2 · 2 credits

Unit I — Fundamentals of robotics: introduction; definition; robot anatomy (parts) and working; robot components — manipulator, end effectors; construction of links, types of joints; classification of robots — Cartesian, cylindrical, spherical, SCARA, vertical articulated; structural characteristics; mechanical rigidity; effects of structure on control, work envelope and work volume; advantages and disadvantages of robots. **Unit II — Robotic drive system and controller:** actuators — hydraulic, pneumatic and electrical drives; linear actuator; rotary drives; AC servo motor, DC servo motors and stepper motors; conversion between linear and rotary motion; feedback devices — potentiometers, optical encoders, DC tachometers; robot controller; levels of controller; open loop and closed loop controller; robot path control — point to point, continuous path control and sensor based path control. **Unit III — Sensors:** requirements of a sensor; principles and applications of position sensors (encoders, resolvers, piezo-electric), range sensors (triangulation principle, structured lighting approach), proximity sensing, force and torque sensing; introduction to machine vision — robot vision system (scanning and digitising image data), image processing and analysis, cameras, vidicon camera (working principle and construction); applications of robot vision — inspection, identification, navigation and sensing. **Unit IV — Robot kinematics and robot programming:** forward kinematics, inverse kinematics and differences; forward and reverse kinematics of manipulators with two degrees of freedom (in 2 dimensions); robot programming languages; VAL programming: motion commands, sensor commands, end effector commands; simple programs. **Unit V — Automation:** basic elements of an automated system, advanced automation functions, levels of automation; industrial applications of robots in machining, welding, assembly and material handling.

Books: Introduction to Robotics — Saeed B. Niku, Pearson, 2006; Industrial Robotics — M.P. Groover, Tata McGraw Hill, 2001; Robotics: Control, Sensing, Vision and Intelligence — Fu, Gonzalez & Lee, McGraw Hill, 1987; Robotics for Engineers — Yoram Koren, McGraw Hill, 1992; A Text Book on Industrial Robotics — Ganesh S. Hedge, Laxmi, 2008; Robotics Technology and Flexible Automation — S.R. Deb & Sankha Deb, Tata McGraw Hill, 2010; Elements of Robotics Process Automation — Mukherjee, Khanna, 2018.

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Option 4 — Advanced Welding & Painting using Simulator (Tata Tech) · 3.7.3 · P 4 · 2 credits

Contents: 1. Introduction to industrial safety practices (fire extinguishers and types; safely handling tools and equipment; use of proper tools and equipment and maintenance; OSH and practices to be observed as a precaution). 2. Introduction to welding (importance in industry; types of welding and selection criteria; filler materials and selection; applications; advantages and disadvantages of welding joints; welding techniques and applications; safety precautions; selection of welding equipment; types of welding joints, applications and symbolic representation on drawings; welding drawing reading and symbols; defects in welding and inspection techniques; welding skill and its impact on product quality). 3. Components of welding equipment and the XR station (power sources — single phase, three phase, transformer, inverter; welding electrodes, electrode holders and types; welding torches and types and selection criteria; high-pressure cylinders and regulators; XR station simulator basic settings and user interface; application and benefit of the XR station simulator; standard operating procedure and safety guidelines; basic troubleshooting and maintenance; industrial case studies). 4. Introduction to industrial painting (importance; paint and its manufacture; paint preparation/mixing as per required shade; types of paints and coatings and selection criteria; technology of painting; adhesives; safety precautions and use of equipment; paint storing guidelines and standard procedure; quality assurance and concept of life span for paint; advancement in painting technology; compliance and regulations). 5. Components of the painting booth, painting materials and technology (paint booth equipment; powder coating spray gun; oven and spray gun, compressor; industry applications of spray painting; advantages and disadvantages of spray painting techniques; types of spray painting components, functional working and settings of painting guns; safety tips for handling spray painting guns; metal surface painting — corrosion, effects, types of emery papers and protection).

Course practicals (20): safety equipment list; list of welding types, selection criteria and applications; checklist as per an industrial welding drawing; chart of welding symbols; list of welding defects; sketch of a welding setup with parts and functions; machine settings using the XR station; torch practice for stroke adjustment, speed, travel angle and work angle; guided welding on simple horizontal and vertical plate/pipe joints; advanced unguided welding on simple horizontal and vertical surfaces; guided and advanced unguided welding on complex job positions; welding joints on the simulator; welding on complex surfaces and positions; spray painting using a spray gun in a paint booth; powder coating and its application; assembly and connection of a spray-painting device, settings using the XR station and gun-holding techniques; guided spraying on complex surfaces (edges, corners, square, round and curved areas) — coverage level, dry areas, defect areas, drip areas, travel lines; case studies; mini project.

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Option 5 — Internet of Things (Tata Tech) · 3.7.5 · L 2 · 2 credits

Contents: 1. Introduction to industrial safety practices. 2. Fundamentals of IoT (introduction; basics of electrical and electronics components used in IoT; history of IoT; applications, benefits and limitations; important components — microcontroller, sensors, actuators, communication protocol, cloud; IoT architecture — physical layer, network layer, data processing layer, application layer). 3. IoT micro-controllers and single board computer (introduction to micro-controllers; types — Arduino, Raspberry Pi; input, output and PWM; interfacing a camera and various sensors to Raspberry Pi; IoT protocols HTTP, MQTT, HTTPS for Raspberry Pi; connecting Raspberry Pi to the cloud; features and specifications of micro-controllers; selection based on the IoT application; basic and advanced programming; debugging and testing of programs). 4. IoT sensors (introduction; types and applications; specifications; working principles; comparison and relative advantages and limitations; selection based on the IoT application; interfacing sensors with a micro-controller; testing sensors for IoT applications). 5. Use of actuators for IoT applications (introduction; types; working principle; applications; comparison; selection). 6. IoT network connectivity (IoT network technologies; connectivity options; comparison; selection based on range, data size, data transfer rate, type of data, number of devices). 7. Cloud and application of IoT (options to store IoT data; comparison; on-premises and cloud storage; IoT database and its selection; interfacing a database with an IoT application; requirements for IoT applications; selection of sensors and actuators; IoT dashboard building; authentication; IoT application building for smart city, healthcare, automotive, manufacturing; IoT mobile application development; use of APIs; basics of machine learning and AI; ML and AI in IoT; industrial use cases).

Course practicals (25): IDE setup and basic code syntax; adding external libraries and boards; LED blink and fading programs; interfacing digital and analog sensors to a micro-controller; uploading and monitoring sensor data to the cloud; interfacing actuators and wireless modules; controlling actuators remotely using IoT; monitoring and alert data system using IoT; Raspberry Pi LED blinking/fading, camera picture and video operations, sensor interfacing, and sending/receiving data to/from the cloud; writing code for an IoT application; developing IoT applications for agriculture, home automation, smart city, manufacturing, automotive, industrial automation and warehouse management; testing an IoT application; case studies.

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Option 6 — Product Verification & Analysis (Tata Tech) · 3.7.6 · L 2 · 2 credits

Contents: 1. Introduction to industrial safety practices. 2. Overview of product design and development (phases of product design and development; concept design, detail design; product verification and validation; user interface, basic settings and customisation for creation of geometry; 2D sketching, 3D modelling; concept creation, modelling, assembly; design modifications; engineering drawing; bill of material; basic understanding of regulatory requirements and testing). 3. FEA and meshing (basics of FEA and meshing; basics of strength of materials; introduction to FEA, FEA steps; types of analysis; FEA software user interface; importing geometry; geometry cleanup and editing; mid-surface extraction; basics of discretisation (meshing) — nodes, elements; selection of mesh/element type based on the structure; mesh parameters; checking mesh quality; refining the mesh). 4. Material, meshing and boundary conditions (applying material properties; basics of types of loads; applying load; defining boundary conditions; rigidity check of the FEA model; solving; post-processing; interpretation of results; countermeasure planning; optimisation of results). 5. Structural and modal analysis (concept of structural and modal analysis; interactive design exploration for static structural; structural conditions — support constraints; force and pressure conditions; remote load conditions; modal analysis — frequency calculation; real-time topology optimisation; post-processing — contour plot viewing; post-processing — report generator; simulation report reading; industrial case study). 6. Buckling analysis and other types of analysis (basic buckling analysis; basic thermal analysis; thermal analysis; thermo-mechanical analysis; simple nonlinear analysis and other advanced types of analysis; interpretation of results; countermeasures and recommendations; industrial case studies).

Course practicals (27): listing industrial safety procedures; creating a sketch, 3D model and assembly; creating a drawing and bill of materials; importing, modifying and cleaning a CAD model; extracting the mid-surface of a model; creating 1D, 2D and 3D elements and meshing (tetrahedral, hexahedral, polyhedral, pyramid or wedge cells); applying material properties; applying boundary conditions (pressure, force, remote force, fixed support); interpreting FEA results; structural analysis of a simply supported beam and of a truss structure; topology optimisation using structural analysis; modal analysis for natural frequencies and for vibration analysis; generating and exporting simulation reports; steady-state thermal analysis of a metal plate and of a heat sink; free-vibration and buckling analysis using FEA software; thermal analysis using FEA software; advanced FEA; design optimisation; preparation of an FEA report.

†Qualifying marks are not added to the awarded division or total marks.

Route 2 — Advance Skill Development (certificate route)

Instead of a taught elective, you may earn the 2 credits with a skill certificate: a minimum of **20 hours** of skill certification from a recognised national or international agency or institute.

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The assessment and certification are conducted by the respective agency or institute, and you present your certificate to earn the credits. The scheme also allows any course of minimum 02 credit from: NPTEL; MOOCs through SWAYAM; AICTE-ELIS and Centrally Funded Technical Institutes; C-DAC; certificates conducted by Institutes of National Importance (IIT, NIT, etc.); ISRO e-learning; and courses offered by Tata Technology or another reputed organisation (including the three Tata Tech courses listed above).

How to Choose — and How to Prepare

Pick the option that matches the work you want to do: material handling and energy audit suit plant and maintenance roles; robotics and the Tata Tech courses suit automation, design and manufacturing roles; the certificate route suits a specific skill you can show an employer. Whichever route you take, remember it is qualifying — you must pass it, so treat the internal assessment (or the certificate) seriously even though the marks do not count towards your division. Check with your polytechnic which options it actually offers this semester: the Tata Tech courses run preferably at Tata Tech centres, and not every option is available at every institute.

Reference Books

Reference books are listed separately under each elective option above (Material Handling Systems, Energy Conservation & Audit, Industrial Robotics & Automation). The three Tata Tech courses list no reference books in the official syllabus; their content is delivered through the course and its practicals.

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Source: BTEUP IRDT Kanpur NEP-2020 curriculum for Diploma in Mechanical Engineering (Automobile), effective session 2025-26 (urise.up.gov.in). Topic lists follow the official syllabus; short explanations are the author's own plain-English summaries, not syllabus text. Please confirm with your own polytechnic for any local changes.