Courses of Study

B.Tech Robotics and Automation

Batch 2024 Onwards

7th Semester

Department of Mechanical Engineering

Islamic University of Science and Technology Kashmir

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Detailed Course Contents for 7th Semester

Total Credits = 23+X *Total Hours Per Week = 31+X*

Course Code	Course Title	L	T	P	S	Credits
MEC405C	Production and Operations Management	3	1	0	0	4
MEC407C	Modelling and Control of Industrial Manipulators	3	0	0	0	3
CSE407C	Computer Vision and Image Processing	2	0	2	0	3
MEC408C	Hydraulics and Pneumatics	2	0	2	0	3
MEC409C	Computer Integrated Manufacturing	2	0	2	0	3
MEC406C	Innovation and Entrepreneurship	2	0	0	0	2
MEC416C	Minor Project	0	0	8	0	4
MEC413C	Industrial Engineering and Ergonomics Lab	0	0	2	0	1
	Open Elective	-	-	-	-	X

MEC405C Production and Operations Management 3-1-0-0

Course Objectives: This course will enable students to get knowledge on production and operation management techniques that develop relationships between market demand and production capability with due consideration to quality assurance of the products and the optimality of the process in terms of resources and time management.

Course Outcomes: At the end of this course, a student will be able to:

1. Explain the scope and basics of production management.
2. Describe the various scientific approaches, tools, and techniques used in project management.
3. Apply production planning and control techniques and inventory management models.
4. Apply the tools and techniques for factory management.
5. Make decisions, and obtain optimal solutions for various situations/problems in production planning and management through the use of operation research tools.

Module I

Introduction: Scope of production management. Production system and resources (machines, tooling, etc.); Types of production, Roles of line supervisors and production managers.

Module II

Project Management: Project life cycle: concept phase, Project initiations, DPR preparation; Project planning: Project team, producing quality outputs, handling risk, acceptance criteria; Project execution; Project Monitoring and control: Project networks, progress review, CPM and PERT, critical path, re-scheduling; Project closure: acceptance of project deliverables; Analytics: Performance, capability aggregation, cost benefit analysis, variability analysis, Output-outcome analysis, project documentation, best practices, and depository.

Module III

Production Planning and Control: Production planning, Process planning, Resource planning, demand-utility mapping (production capability index, forecasting models, aggregate production planning, materials requirement planning); Inventory Management: Economic order Quantity, discount models, stochastic inventory models, practical inventory control models, JIT; Supply chain and management.

Module IV

Factory Management: Factory layout: line balancing, material flow and handling, Lean and green manufacturing, Human resource management, Training need analysis, Advantage and opportunities for Digitalization, Advanced factory systems: TQM; Important acts, regularities and safety norms, Reliability assessment of processes, Process capability, lean manufacturing.

Module V

Operations Management: Linear programming, objective function and constraints, graphical method, Simplex and duplex algorithms, transportation assignment; Simple queuing theory models; Traveling Salesman problem; Network models: shortest route, minimal spanning tree, maximum

flow model.

Text Books:

1. R. Panneerselvam, Production and Operations Management, Prentice Hall India, 2012.
2. L. J. Krajewski and L. P. Ritzmen, Operations Management: Strategy and Analysis, Pearson, 2001.
3. W. J. Hopp and M. L. Spearman, Factory Physics: Foundations of Manufacturing Management, McGraw Hill, 2000.
4. H. A. Taha, Operations Research: An Introduction, Prentice Hall India, 1997.

Reference Books:

1. R. B. Chase, F. R. Jacobs and N. J. Aquilano, Operations Management for Competitive Advantage, Tata McGraw Hill, 2003.
2. B. Mahadevan, Operations Management: Theory and Practice, Pearson, 2015.
3. M. P. Poonia and S. C. Sharma, Total Quality Management, Khanna Publishing House, 2020.

Online Resources:

1. Production and Operations Management by Prof. Rajat Agarwal (IIT Roorkee), SWAYAM/NPTEL Course (https://onlinecourses.nptel.ac.in/noc20_mg06/preview).

MEC407C Modelling and Control of Industrial Manipulators 3-0-0-0

Course Objectives: The objective of this course is to equip students with fundamental knowledge and practical skills in industrial robotics, focusing on robot kinematics, statics, dynamics, trajectory planning, and simulation. It aims to develop competency in analyzing and designing serial chain robotics, understanding motion behavior, and integrating robotics into smart manufacturing environments through modern tools such as ROS, Gazebo, and MATLAB-based platforms.

Course Outcomes: At the end of this course, a student will be able to:

1. Apply kinematic modeling techniques to analyze and simulate industrial robot motion.
2. Analyze static behavior and mechanical design of robot structures and end-effectors.
3. Derive dynamic models for robotic arms and simulate their behavior.
4. Design smooth and feasible motion trajectories for industrial manipulators.
5. Evaluate robotic systems and their applications using simulation platforms and Industry 4.0 tools.

Module I: Robot Kinematics and Workspace Analysis
Forward kinematics using Denavit–Hartenberg (DH) parameters; inverse kinematics for serial manipulators; differential kinematics and velocity relationships; Jacobian matrix computation and singularities; workspace mapping and manipulability; simulation of robot motion and pose analysis.

Module II: Robot Statics, Design, and End-Effectors
Force and torque balance in robotic arms; static equilibrium and load distribution; design criteria for robot links and joints; stress-strain considerations and material selection; types and functions of grippers and end-effectors; task-specific design; CAD-assisted end-effector modeling.

Module III: Robot Dynamics and Simulation
Dynamic modeling using Lagrange–Euler and Newton–Euler formulations; equations of motion for serial and parallel robots; actuator dynamics and simplified joint control overview; implementation using MATLAB, Simscape, or similar simulation tools; analysis of robot motion profiles and forces.

Module IV: Trajectory Planning and Motion Control
Trajectory generation in joint and Cartesian space; point-to-point and continuous path planning; velocity, acceleration, and jerk constraints; time-scaling and polynomial interpolation; basics of motion control and trajectory tracking; hands-on implementation in MATLAB/Simulink or ROS.

Module V: Human-Robot Collaboration and Smart Manufacturing Tools
Human-robot interaction principles; safety and cooperative task design; integration of robotics in Industry 4.0 environments; introduction to ROS architecture and Gazebo simulation; use of RoboAnalyzer and MATLAB Robotics Toolbox for system modeling, control, and visualization; demonstration of smart robotic workflows.

Text Books:

1. Craig, J. J. (2017). *Introduction to robotics: Mechanics and control* (4th ed.). Pearson.
2. Groover, M. P., Weiss, M., Nagel, R. N., & Dutta, A. (2007). *Industrial robotics: Technology, programming, and applications* (2nd ed.). McGraw-Hill Education.

Reference Books:

1. Niku, S. B. (2010). *Introduction to robotics: Analysis, control, applications* (2nd ed.). Wiley.
2. Siciliano, B., Sciavicco, L., Villani, L., & Oriolo, G. (2009). *Robotics: Modelling, planning and control*. Springer.
3. Corke, P. (2017). *Robotics, vision and control: Fundamental algorithms in MATLAB* (2nd ed.). Springer.
4. Joseph, L. (2018). *Robot Operating System (ROS) for absolute beginners*. Apress.

Online Resources:

1. Industrial Robotics : Theories For Implementation, By Prof. Arun Dayal Udai (IIT-ISM Dhanbad), NPTEL Course (https://onlinecourses.nptel.ac.in/noc23_me143/preview).

CSE407C Computer Vision and Image Processing 2-0-2-0

Course Objectives: This course introduces students to the fundamentals of computer vision, covering essential concepts and practical techniques. Participants will learn to apply basic image processing methods, extract key features from images, and implement classical machine learning algorithms for vision tasks. The course also explores deep learning approaches to computer vision, enabling students to develop advanced image analysis solutions. Through hands-on projects, learners will gain experience in building and optimizing computer vision systems for real-world applications

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Course Outcomes: At the end of this course, a student will be able to:

1. Explain core concepts of computer vision.
2. Perform basic image processing operations.
3. Extract and analyze features from images.
4. Develop and evaluate machine learning and deep learning models for computer vision.

Module I

Introduction to Computer Vision: Definition and applications of computer vision, Understanding images and pixels, Grayscale and colour images, Basic image processing operations, Image formats and conversions.

Module II

Basic Image Processing : Reading, displaying, and saving images, Basic operations (resizing, cropping, rotating), Image filtering (blurring, sharpening, edge detection), Drawing shapes and text on images, Handling image channels and colour spaces.

Module III

Feature Extraction: Traditional Feature Detectors: Edge detection, Corner detection, SIFT and SURF features, ORB features**,** Image Segmentation: Thresholding, Watershed algorithm, Contours and shape detection, Region growing.

Module IV

Deep Learning for Computer Vision: Convolutional Neural Networks (CNN), Convolution Layers, Pooling Layers, Fully Connected Layers.

List of Practicals:

1. Load a color image, convert to grayscale, display pixel values, and save in PNG/JPEG formats.
2. Resize, crop, and rotate an image using OpenCV, then display the results.
3. Apply Gaussian blur and Canny edge detection to an image and visualize outputs.
4. Draw a rectangle and text on an image, convert it to HSV, and modify the saturation channel.
5. Implement Sobel edge detection and Harris corner detection, visualizing results.
6. Detect and visualize ORB keypoints in an image, matching features between two images.
7. Apply Otsu's thresholding and visualize segmented regions.
8. Detect contours in a binary image, calculate areas, and draw them on the original image.

9. Build a simple CNN with convolution and pooling layers, train on MNIST, and plot accuracy.
10. Use a pre-trained VGG16 model to classify an image and visualize predictions.
11. Create a project that focuses on recognizing hand gestures in real-time.
12. Create a project that involves building a system to detect and recognize street signs.

Prerequisites: Basic Programming Skills

Textbooks:

1. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer.
2. R. Hartley and A Zisserman, Multiple View Geometry in Computer Vision, Cambridge University Press.

Reference Books:

1. K.P. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press.
2. J. Howse, OpenCV Computer Vision Projects with Python, Packt Publishing.
3. A. Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, Shroff/O'Reilly Publishers.
4. I. Goodfellow, Y. Bengio, and A. Courville "Deep Learning", MIT Press.

Online Resources:

1. Introduction to Computer Vision by the University at Buffalo and the State University of New York.
2. Deep Learning for Computer Vision by the National Research University Higher School of Economics (https://www.coursera.org/learn/deep-learning-computer-vision).
3. Computer Vision Basics by the University of Colorado Boulder.

MEC408C Hydraulics and Pneumatics 2-0-2-0

Course Objectives: This course provides students with a foundational understanding of hydraulic and pneumatic systems, covering their core principles, components, and applications. Students will study hydraulic pumps, motors, actuators, valves, and fluids, along with their roles in circuit design and operation. The course also explores pneumatic systems, including compressors, filters, regulators, and valves, while teaching selection criteria for optimal performance. Through practical exercises, learners will design and analyze basic hydraulic and pneumatic circuits, gaining hands-on skills for industrial applications.

Course Outcomes: At the end of this course, a student will be able to:

1. Ability to analyze and evaluate hydraulic and pneumatic systems and their components in real-world applications.
2. Explain the working of the different components of hydraulic systems.
3. Design and analyze basic pneumatic circuits, understanding the role of key components like compressors, cylinders, and air motors.
4. Demonstrate knowledge of hydraulic and pneumatic components such as valves, actuators, and transmission systems, and their integration into fluid power systems for optimal performance.
5. Explain the basic Pneumatic Circuits.

Module I: Fundamentals of Hydraulic Systems

Introduction to fluid power; global hydraulic scenario; advantages and disadvantages of hydraulic systems; basic principles of hydraulic power; standard hydraulic and electrical symbols; hydraulic fluids – types, properties, classification (mineral-based, fire-resistant, biodegradable); fluid contamination and filtration techniques.

Module II: Hydraulic Components and Actuators

Hydraulic pumps – classification and working (gear, vane, axial and radial piston pumps); hydraulic motors – types and applications; linear and rotary actuators – characteristics and efficiency; hydrostatic transmission systems (HST) – principles and uses.

Module III: Hydraulic Valves, Accessories and Circuits

Control valves – directional, pressure, flow control, and non-return types; hydraulic accessories – reservoirs, accumulators, seals, heaters, and coolers; basic and industrial hydraulic circuits; power losses in hydraulic systems.

Module IV: Pneumatic Systems and Circuit Design

Pneumatic systems – definition, advantages, limitations, and applications; air compressors – types and selection; pneumatic system components – air receivers, FRL unit, pipeline layout; pneumatic actuators – cylinders, motors, mounting and cushioning; control valves – directional, quick exhaust, time delay, shuttle, and twin pressure valves; basic and multiple actuator pneumatic circuits; sequencing methods – cascade method. Basic pneumatic circuits: Development of single actuator Circuits and multiple actuator circuits, Cascade method for sequencing.

List of Practicals

1. Identification of Hydraulic Components, symbols and build a basic circuit.
2. Demonstration and Comparison of Hydraulic Pumps (Gear, Vane, and Piston)
3. Study of Hydraulic Valves in a Control Circuit
4. Assemble a simple hydraulic circuit with a pump, directional control valve, and actuator.
5. Flow Control and Speed Regulation in Hydraulic Actuators
6. Assembly and Testing of Basic Hydraulic Circuit for Double-Acting Cylinder.
7. Design and Operation of an Industrial Hydraulic Circuit (e.g., Press or Clamp)
8. Identification of Pneumatic Components, Symbols and build a basic circuit.
9. Design and Testing of a Pneumatic System with FRL Unit
10. Operation of Single-Acting and Double-Acting Cylinders with Directional Control Valves
11. Development of a Multiple Actuator Circuit Using the Cascade Method
12. Design a circuit with a single pneumatic cylinder, a directional control valve, and a quick exhaust valve, measuring speed and force.
13. Time-Delay Pneumatic Circuit Using Pneumatic Timer,
14. Simulation of Hydraulic and Pneumatic Circuits.

Text Books:

1. A. Parr, Hydraulics and Pneumatics: A Technician's and Engineer's Guide, Newnes (Elsevier), 1st Edition, ISBN-13: 978-0750651020.
2. James R. Daines, Introduction to Fluid Power, Cengage Learning, 1st Edition, ISBN-13: 978-1111531440.
3. Anthony Esposito, *Fluid Power with Applications*, Pearson Education, 7th Edition, ISBN-13: 978-0133457776.
4. P. L. Ballaney, Fluid Power Systems and Control, Khanna Publishers, 1st Edition, ISBN-13: 978-8174090806.

Reference Books:

1. H. E. Merritt, Hydraulic Control Systems, Wiley, 1st Edition, ISBN-13: 978-0471034289.

Online Resources: Industrial Hydraulics by Dr. Suman Chakraborty, IIT Kharagpur (NPTEL Course) https://nptel.ac.in/courses/112105269

MEC409C Computer Integrated Manufacturing 2-0-2-0

Course Objectives: This course aims to equip students of the Robotics and Automation program with foundational and practical knowledge of Computer Integrated Manufacturing (CIM), focusing on the integration of CAD/CAM, CNC systems, adaptive and flexible manufacturing, and Industry 4.0 technologies. It emphasizes the use of robotics, smart systems, and digital tools for designing, simulating, and optimizing automated manufacturing processes.

Course Outcomes: At the end of this course, a student will be able to:

1. Understand the architecture and components of CIM systems and their integration.
2. Analyze and design adaptive and smart manufacturing systems aligned with Industry 4.0.
3. Apply group technology and cellular manufacturing concepts for layout and flow optimization.
4. Develop and simulate automated manufacturing systems using CNC, robotics, and digital tools.

Module I

Introduction to Computer Integrated Manufacturing (CIM): Evolution of manufacturing systems, CIM architecture and components, CAD/CAM integration, CNC and DNC systems, automated process planning, data exchange formats (STEP, IGES).

Module II

Adaptive Manufacturing Systems

Flexible Manufacturing Systems (FMS) architecture, Reconfigurable Manufacturing Systems (RMS), Agile manufacturing principles, Tool and part handling systems (AGVs, AS/RS), Lean manufacturing and quick changeover techniques.

Module III

Smart Manufacturing and Industry 4.0

Industry 4.0 enabling technologies, cyber-physical systems (CPS), industrial IoT, cloud manufacturing, artificial intelligence and machine learning in manufacturing, big data analytics, cybersecurity, predictive maintenance, and real-time process monitoring.

Module IV

Cellular and Group Technology

Part families and features classification, Optiz parts classification and coding systems, Production flow analysis and composite part concept, Application of Group Technology, Quantitative analysis and group techniques, Digital Manufacturing and Simulation: Digital twins, robotic workcell simulation, human-robot collaboration.

List of Practicals:

1. Simulate a CIM system integrating CAD/CAM and CNC using software tools.
2. Program a 3-axis CNC milling operation using G-code.
3. Design and simulate a flexible manufacturing cell layout using FlexSim or Tecnomatix.
4. Create a digital twin of a manufacturing process using simulation software.

5. Introduction to smart factory layout.
6. Demonstrate AGV routing in a simulated smart factory environment.
7. Analyze and optimize a robotic or automated workcell using layout simulation tools.
8. Perform robotic palletizing using offline programming tools.
9. Program and analyse 6DOF industrial robot for pick and place tasks.
10. Program and analyse the motion of parallel manipulator.
11. Analyze manufacturing process data to enable predictive maintenance.
12. Design a machine cell layout using group technology principles and simulation tools.
13. Evaluate machine utilization in a designed cellular manufacturing layout.

Text Books:

1. Mikell P. Groover, *Automation, Production Systems, and Computer-Integrated Manufacturing*, 4th Edition, Pearson Education, 2015.
2. Yoram Koren, *Computer Integrated Manufacturing Systems*, McGraw Hill, 1983.
3. Radhakrishnan P., Subramanyan S. and Raju V., *CAD/CAM/CIM*, 3rd Edition, New Age International Publishers, 2008.

Reference Books:

1. Rehg, James A., and Kraebber, Henry W., *Computer Integrated Manufacturing*, 3rd Edition, Pearson Education, 2004.
2. Zuehlke, Detlef, *SmartFactory – Towards a Factory-of-Things*, Annual Reviews in Control, Elsevier, 2010.
3. Khan, M. I., and Vohra, N., *Industry 4.0 and Advanced Manufacturing*, Cengage Learning, 2022.

Online Resources: https://onlinecourses.nptel.ac.in/noc22_me10/preview

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MEC406C Innovation and Entrepreneurship 2-0-0-0

Course Objectives: This course aims to expose aspiring student entrepreneurs to various elements of a technology venture, from market need identification to innovative solution development and its commercialization through business planning and start-up company incubation.

Course Outcomes: At the end of this course, a student will be able to:

1. To understand the essential concepts of entrepreneurship.
2. Develop innovative ideas and demonstrate an understanding of the entrepreneurial process, including opportunity recognition, feasibility analysis, and market validation.
3. Apply relevant tools and techniques for marketing, financing, and scaling a startup.

Module I

Entrepreneurship: concept, characteristics, and prerequisites. Classification of entrepreneurship. Factors underlying the success and reasons for the failure of entrepreneurship. Role of entrepreneurship in economic development. Challenges in starting a new venture.

Module II

New product development: New product development lifecycle, Product-market fit validation. Creativity and innovation, Understanding the creative process. Developing ideas and business opportunities—methods of generating new ideas, Opportunity scanning,

Module III

Product Innovation: Definition and Significance of Product Innovation The role of innovation in business strategy. Market analysis and feasibility planning. Writing and presentation of a business plan.

Module IV

Design & prototyping: Importance of design and prototyping. Design thinking and the design process. Introduction to prototyping tools and materials. Functionality and manufacturability. Intellectual property rights. Intellectual property infringement.

Module V

Marketing & Finance: Marketing and Sales for Entrepreneurs, Product positioning and branding, Sales strategies, and customer acquisition. Financing the venture-early-stage financing, and growth funding. Source of funding for startup ventures; financial projections and accounting; Startup to scale up financing. Entrepreneurial support system in India Social impact & responsibility.

Text Books:

1. J. Bessant and J. Tidd, Innovation and Entrepreneurship, Wiley,(2015).
2. D. F. Kuratko and R. M. Hodgetts, Entrepreneurship: Theory, Process, and Practice, Cengage Learning, (2018).
3. D. Byers, and Nelson, Technology Ventures: From Ideas to Enterprise, McGraw Hill,

4. B. R. Barringer and R. D. Ireland, Entrepreneurship: Successfully Launching New Ventures, Pearson, (2019).

Online Resources:

1. https://archive.nptel.ac.in/courses/110/106/110106141/

MEC357C Industrial Engineering and Ergonomics Lab 0-0-2-0

Course Objectives: This course will enable students to develop skills in production planning simulation and to apply the concepts of human factors considerations and work study tools in industrial practice.

Course Outcomes: At the end of this course, a student will be able to:

1. Conduct modelling and simulation exercises on production planning using software.
2. Use ergonomic and human factors in the design of various products.
3. Apply work study tools to enhance productivity in industrial units.

List of Exercises and Experiments

1. Introduction to Witness simulation software: Modelling overview, conducting a simulation project, witness rules. Exercises on witness simulation software on the following:
    i. Manufacturing modelling
    ii. Warehouse modelling
    iii. Multi-cycle machine and labour modelling
    iv. Supply chain and logistics modelling
2. Experiment on the effect of background noise/music on cognitive task performance.
3. Experiment on body movement ranges with special emphasis on head, leg, arm and hip.
4. Experiment on anthropometric considerations for seating.
5. Exercise-cum-mini project on ergonomic considerations in the design specifications of a product.
6. Exercise on the application of method study approach to analyse the motions involved in machining operation of a given job.
7. Exercise on application of work measurement technique to analyse the time components involved in machining operation of a given job.
8. Study suitable movements/travel of man, material or equipment, and draw string diagrams, travel charts and flow diagrams.
9. Introduction to softwares for project managers like Lucidchart, Microsoft Project, Smartdraw etc.
10. Exercises on PERT/CPM charts using software packages.

Online Resources:

1. https://www.lanner.com/en-gb/technology/witness-simulation-software.html

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