**Medical Robotics and Devices**

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| **S.No** | **Code** | **Name of the Course** | **Offered** |
| 1 |  | Fundamentals of Robotics | Mech |
| 2 |  | Medical Device Design | BME |
| 3 |  | Robotic System Programming | BME |
| 4 |  | Micro and Nano Medical Robotics | BME |
| 5 |  | Robotics in Bioprosthetics | BME |
| 6 |  | Surgical and Rehabilitation Robotics | BME |

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| **MEDICAL DEVICE DESIGN** | | **L** | **T** | **P** | | **C** |
| **3** | **0** | **0** | | **3** |
| **Course Objective:**  To impart knowledge on   * To describe the design procedure of medical devices. * To understand the medical device standards and requirements and concept generation. * To explain the validation and verification of various medical devices. | | | | | | |
| **Course Outcome:**  At the end of the course, the students will be able to   * Explore the fundamentals of medical product design procedures. * Analyze the medical devices standards and its regulatory schemes. * Elucidate the concept of medical device development. * Illustrate the development strategy for medical product. * Apply the testing and validation procedure for medical equipment. | | | | | | |
| **Unit I** | **MEDICAL PRODUCT DESIGN** | | | | **9** | |
| Definition, History and Modern Practice – Designs; Design and Product Life Cycle; Design Process; Understanding the innovation cycle, Good Design Practice. Understanding, analyzing and validating user needs, Screening Needs, Technical Requirements, Safety and Risk analysis. | | | | | | |
| **Unit II** | **MEDICAL DEVICES STANDARDS** | | | | **9** | |
| Design Control & Regulatory Requirements, Documentation in Medical Devices, Regulatory pathways, Evaluation of Medical Devices -ISO Medical Devices – Applications of Risk Management to Medical Devices (ISO 14971), Electrical Safety Standard - IEC60601-1, IEC60601-2, IEC60601-6, Protection of Electrical and Electronic parts. | | | | | | |
| **Unit III** | **CONCEPT GENERATION AND SELECTION** | | | | **9** | |
| Ideation and Brainstorming – concept screening, concept selection. Operating plan and financial model – Business plan development, funding sources, licensing and alternate pathways. | | | | | | |
| **Unit IV** | **DEVELOPMENT STRATEGY AND PLANNING** | | | | **9** | |
| Intellectual property strategy, research and development strategy, clinical strategy, regulatory strategy – quality and process management, reimbursement strategy, marketing and stakeholder strategy, sales and distribution strategy. | | | | | | |
| **Unit V** | **TESTING AND VALIDATION** | | | | **9** | |
| Basis and types of testing, Hardware verification and data analysis, software verification and data analysis, Protecting Intellectual property, Regulatory approval. | | | | | | |
| **TOTAL: 45 PERIODS** | | | | | | |
| **Text Book:**   1. Zenios, Makower and Yock, “Biodesign – The process of innovating medical technologies”, Canbridge University Press, 2009. 2. Peter Ogrodnik, “Medical Device Design Innovation from Concept to Market”, Elsevier, 2013. | | | | | | |
| **Reference Book:**   1. Matthew Bret Weinger, Michael E. Wiklund, Daryle Jean Gardner-Bonneau, “Handbook of Human Factors in Medical Device Design”, CRC press, 2010. 2. Theodore R. Kucklick, “The Medical Device R&D Handbook”, Second Edition, CRC Press, 2012. 3. Gail Baura-“Medical Device Technologies: A Systems Based Overview Using Engineering Standards”, Academic Press, Year: 2020. | | | | | | |
| **Extensive Reading:**   * https://www.futurelearn.com/courses/medtech-trends-and-product-design * <https://www.udemy.com/course/iso-134852016-design-and-development-of-medical-devices/> * <https://in.coursera.org/specializations/healthcare-marketplace> * https://onlinecourses.nptel.ac.in/noc20\_ge14/preview | | | | | | |

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| **ROBOTIC SYSTEM PROGRAMMING** | | **L** | **T** | **P** | | **C** |
| **3** | **0** | **0** | | **3** |
| **Course Objective:**  To impart knowledge on   * To understand the ROS concepts and its Programming. * To simulate ROS using various simulator tools. * To familiarise the applications of ROS. | | | | | | |
| **Course Outcome:**  At the end of the course, the students will be able to   * Explore the functions of ROS components. * Develop programming for ROS file handling concepts. * Analyse various commands and tools in ROS. * Develop programs using simulation tools. * Build ROS based Robotic application. | | | | | | |
| **Unit I** | **FUNDAMENTALS OF ROS** | | | | **9** | |
| Introduction - Robot Software Platform, Need for Robot Software Platform, Meta-Operating System - Objectives of ROS - Components of ROS - ROS Ecosystem - ROS Versions - Version Rules, Version Release Period, Selecting a Version. ROS services - C++ Classes In ROS - Creating Library Modules in ROS - Action Servers and Action Clients - Parameter Server. | | | | | | |
| **Unit II** | **CONCEPTS OF ROS** | | | | **9** | |
| ROS terminologies, Message Communication – Topic, Service, Action, Parameter, Message Communication Flow, Message - msg File, srv File, action File - Name - Coordinate Transformation - Client Library - Communication between Heterogenous Devices - File System - File Configuration, Installation folder, Workspace Folder - Build System- Creating a Package, Modifying the Package Configuration File, Modifying the Build Configuration File, Writing Source Code, Building the Package and Running the Node. | | | | | | |
| **Unit III** | **ROS COMMANDS AND TOOLS** | | | | **9** | |
| ROS Command List - ROS Shell Commands - ROS Execution Command - ROS Information Commands - ROS Catkin Commands - ROS Package Commands. ROS Tools - 3D Visualization Tool (RViz) and ROS GUI Development Tool. | | | | | | |
| **Unit IV** | **ROS PROGRAMMING AND SIMULATION** | | | | **9** | |
| Publisher and Subscriber Nodes- Building nodes, running publisher and Subscriber, Communication Status of running nodes, Server and Client Nodes- Writing Server node, Running Service client, ROS launch-Using ROS launch, launch tag, TurtleBot Development Environment- TurtleBot3 Simulation using Rviz, TurtleBot3 Simulation using Gazebo | | | | | | |
| **Unit V** | **APPLICATIONS OF ROS** | | | | **9** | |
| Navigation stack-creating transforms -odometer – IMU – laser scan – base controller – robot configuration – cost map – base local planner – global planner – localization – sending goals – TurtleBot – the low-cost mobile robot, Embedded system-OpenCV, Ros-serial, TurtleBot3 Firmware | | | | | | |
| **TOTAL: 45 PERIODS** | | | | | | |
| **Text Book:**   1. Yoonseok Pyo, Hancheol Cho, RyuWoon Jung, TaeHoon Lim, “ROS Robot Programming”, ROBOTIS, 2017. 2. Wyatt Newman, “A Systematic Approach to learning Robot Programming with ROS”, CRC Press, 2017. | | | | | | |
| **Reference Book:**   1. Lentin Joseph, “Robot Operating Systems (ROS) for Absolute Beginners”, Apress, 2018 2. Aaron Martinez, Enrique Fernandez, “Learning ROS for Robotics Programming”, Packt Publishing Ltd, 2013. 3. Jason M O'Kane, “A Gentle Introduction to ROS”, CreateSpace, 2013. 4. AnisKoubaa, “Robot Operating System (ROS) – The Complete Reference”, (Vol.3), Springer, 2018. 5. Kumar Bipin, “Robot Operating System Cookbook”, Packt Publishing, 2018. 6. Patrick Gabriel, “ROS by Example: A do it yourself guide to Robot Operating System”, Lulu, 2012. | | | | | | |
| **Extensive Reading:**   * <http://wiki.ros.org/ROS/Tutorials> * <https://www.udemy.com/course/ros-essentials/> * <https://www.edx.org/course/hello-real-world-with-ros-robot-operating-system> * https://nptel.ac.in/courses/107106090 | | | | | | |

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| **MICRO AND NANO MEDICAL ROBOTICS** | | **L** | **T** | | **P** | **C** |
| **3** | **0** | | **0** | **3** |
| **Course Objective:**  To impart knowledge on   * To familiarize the principles of micro and nano medical robots. * To learn tracking technologies in imaging and capsule robots. * Analyze the applications of robots in cardiovascular and cancer treatment. | | | | | | |
| **Course Outcome:**  At the end of the course, the students will be able to   * Explore the fundamentals of micro and nano medical robots. * Paraphrase the tracking technologies of robots in imaging. * Apply robotics concept in cardiovascular treatment. * Illustrate the technologies in capsule robot. * Elucidate various robotic technologies in cancer treatment. | | | | | | |
| **UNIT I** | **MEDICAL MICRO AND NANO ROBOTS** | | | **9** | | |
| Introduction, Medical microscale nanorobots versus microrobots, Actuation- Magnetic propulsion, Bacterial propulsion, Steering and navigation of microrobots-Magnetotaxis based steering, Positioning and tracking of nanorobots. | | | | | | |
| **UNIT II** | **TRACKING OF ROBOTS IN IMAGING TECHNOLOGIES** | | | **9** | | |
| Characterization of motion- In aqueous environment, In complex environment, Tracking technologies-Fluorescence imaging, MRI Technology, Radionuclide imaging, Ultrasonic imaging. | | | | | | |
| **UNIT III** | **ROBOTS FOR CARDIOVASCULAR TREATMENT** | | | **9** | | |
| Thrombus- Tubular microrobot, MMNM/PM nanorobots, PDA nanorobot, Atherosclerosis- NIR driven microrobot, Carrier free trehalose based nanorobot, Cerebral apoplexy-Powered Mg based microrobots. | | | | | | |
| **UNIT IV** | **CAPSULE ROBOTS IN GI TRACT** | | | **9** | | |
| Robotic capsule technology, Conceptual design of capsule robot- Design principles, Conceptual design, In vivo imaging and localization of microrobots, Navigation and control of capsule robot- Operating modes, Behavior based robot programming, Webot 3D robotic simulator. | | | | | | |
| **UNIT V** | **MICRO AND NANO ROBOTS FOR CANCER TREATMENT** | | | **9** | | |
| Cancer diagnosis- Monoclonal antibody functionalized micro robots, Nano wire robot, Magnetic fluorescence nano robots, DNA nanorobots, Targeting and delivery, Treatment- Treatment mechanism, Chemotherapy, Metabolic therapy, Gas therapy, Bio therapy, Immuno therapy. | | | | | | |
| **TOTAL: 45 PERIODS** | | | | | | |
| **Textbook:**   1. [Chun Mao](https://www.wiley.com/en-ae/search?filters%5Bauthor%5D=Chun+Mao&pq=++), [Mimi Wan](https://www.wiley.com/en-ae/search?filters%5Bauthor%5D=Mimi+Wan&pq=++) , “Biomedical Micro- and Nanorobots in Disease Treatment - Design, Preparation, and Applications”, Hardcover, 2023. 2. Klaus D Sattler, “Handbook of nanophysics - Nanomedicine and nanorobotics”, Taylor & Francis, 2009. | | | | | | |
| **Reference Book:**   1. Yi Guo (auth.), Yi Guo (eds.), “Selected Topics in Micro\_Nano-robotics for Biomedical Applications” Springer-Verlag New York 2013. 2. Yu Sun, Xian Wang, Jiangfan Yu, “Field-Driven Micro and Nanorobots for Biology and Medicine”, Springer 2021. 3. Ki-Taek Lim, Kamel A. Abd-Elsalam, “Nanorobotics and Nanodiagnostics in Integrative Biology and Biomedicine”, Springer 2022. | | | | | | |
| **Extensive Reading:**   1. https://www.frontiersin.org/articles/10.3389/fbioe.2018.00170/full 2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9584632/ 3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7407549/ 4. https://nptel.ac.in/courses/112105249 | | | | | | |

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| **ROBOTICS IN BIOPROSTHETICS** | | **L** | **T** | | **P** | **C** |
| **3** | **0** | | **0** | **3** |
| **Course Objective:**  To impart knowledge on   * To explore the concepts of Bio prosthetics and its materials. * To assess the gait for prosthetic fabrication. * To develop improved prosthetic devices for amputated limbs. * To design different automated prosthetic models. | | | | | | |
| **Course Outcome:**  At the end of the course, the students will be able to   * Explore the concept of Bio-prosthesis. * Analyse the normal and pathological Gait. * Analyse the materials used for prosthetic fabrication. * Illustrate advanced prosthetics technologies. * Develop Bio Robots for various clinical applications | | | | | | |
| **UNIT I** | **BIO-PROSTHETICS** | | | **9** | | |
| Introduction- History of Prosthetics Early years and Modern Times. Prosthetic components - Prescription criteria, Ankle/Foot Mechanism, disarticulation, Transtibial and Transfemoral Prosthesis, Hip disarticulation/Transpelvic. Bilateral Amputation. Lower Extremity Prosthetics Management – Prosthetic fitting decisions, transtibial and transfemoral prosthetics evalutation, transtibial and transfemoral gait analysis, Donning the prosthesis, Prosthetic training. Prosthetic replacements for the hand,wrist and forearm, prosthetic fitting | | | | | | |
| **UNIT II** | **GAIT & PROSTHETICS** | | | **9** | | |
| Normal Gait, Kinetic and Kinematic Descriptors of human walking, Gait Cycle - weight acceptance, single limb support, limb advancement. Describing Pathological Gait - common gait deviations observed during stance and swing. Qualitative gait assessment. Instrumented gait analysis - technology in gait assessment, Function based assessment. Clinical Examples of Gait Deficiencies: Impact of Functional Tasks During Gait. | | | | | | |
| **UNIT III** | **MATERIALS AND FABRICATION PROCESS** | | | **9** | | |
| Materials used for prosthesis, Prescription Guidelines- Prosthetic prescription. Fabrication process – Measurement, Fabricating and modifying the positive model. Computer-aided design/ computer-aided manufacture - Data acquisition, shape-manipulation software, milling and production. Central fabrication and mass production. Technologies Poised to Transform Prosthetics and Rehabilitation .Maintenance of prostheses. | | | | | | |
| **UNIT IV** | **PROSTHETIC AND ROBOTIC MECHANISM** | | | **9** | | |
| Mechatronic Hands- Myoelectrically controlled hands, Components, Mechanisms and actuators, Power sources, Prosthetic socket. Mechanisms- Materials, Simple clamps, Curling fingers and pulleys, one four-bar linkage, two four-bar linkages. Sensors- Forces sensors, Slip and texture sensors, Position (angle). Control - Finger position, Object slip. Hand assessment – Procedure, Calculations, Manufacture, Standardisation, Reliability and validity. | | | | | | |
| **UNIT V** | **APPLICATIONS OF ROBOTICS IN BIO PROSTHESIS** | | | **9** | | |
| Bionic Arm- Kinematics of AdeptThree Robot Arm, Robotic Grasping of Unknown Objects, Object-Handling Tasks Based on Active Tactile and Slippage Sensations. Robot Arm to Intentional Agent: The Articulated Head - Inter-Component Communication and Sensing, Attention model.Bio-inspired control for robot arms. | | | | | | |
| **TOTAL: 45 PERIODS** | | | | | | |
| **Text Book:**   1. Bella J. May, “Amputations and Prosthetics A Case Study Approach”, Second Edition. Jaypee Brothers Medical Publishers (P) Ltd New Delhi, 2002 2. Kevin K.Chui, “Orthotics and Prosthetics in Rehabilitaion”, Fourth Edition by Elsevier, 2020. | | | | | | |
| **Reference Book:**   1. Jacob Rosen, Blake Hannaford and Richard M. Satava , Editors, “Surgical Robotics Systems Applications and Visions”, Springer 2011 2. Satoru Goto ,”Robot Arms”, InTech Publisher 2011. 3. Robert Schilling, “Fundamentals of Robotics-Analysis and control”, Prentice Hall, 2018. 4. J.J.Craig, “Introduction to Robotics”, Pearson Education, 2017. 5. Staugaard, Andrew C,”Robotics and Artificial Intelligence: An Introduction to Applied Machine Learning”, Prentice Hall Of India, 1987. | | | | | | |
| **Extensive Reading:**   1. [http://www.springer.com/engineering/biomedical+engineering/book/978-1-4419-1125-4](http://www.springer.com/engineering/biomedical%2Bengineering/book/978-1-4419-1125-4) 2. Surgical Robotics: Systems Applications and Visions (by Rosen, Jacob, Hannaford, Blake, Satava, Richard M. (Eds.)) 3. <http://onlinelibrary.wiley.com/journal/10.1002/%28ISSN%291478-596X> (The International Journal of Medical Robotics and Computer Assisted Surgery) 4. <http://medrobotics.ri.cmu.edu/node/128439>(Medical Robotics at CMU) 5. <http://robotics.eecs.berkeley.edu/medical/>(Medical Robotics at UC Berkeley) 6. https://nptel.ac.in/courses/112107289 | | | | | | |

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| **SURGICAL AND REHABILITATION ROBOTICS** | | **L** | **T** | | **P** | **C** |
| **3** | **0** | | **0** | **3** |
| **Course Objective:**  To impart knowledge on   * To introduce concepts of Surgical and Rehabilitation Robotics. * To assess the Rehabilitation with the help of robotics. * To apply Robotics Surgical system in various operations. * To familiarise smart materials in Robotics Surgery. | | | | | | |
| **Course Outcome:**  At the end of the course, the students will be able to   * Explore the knowledge of Surgical and Rehabilitation Robotics. * Demonstrate advanced robotics technologies in surgery. * Analyze the design criteria of rehabilitation robotics * Analyze Quantitative assessment for Rehabilitation. * Apply smart materials in Robotic Surgery. | | | | | | |
| **UNIT I** | INTRODUCTION TO SURGICAL ROBOTICS | | | **9** | | |
| Introduction to Robotic Surgery. Robotic Systems in Human Surgery - Surgical Robotic Systems and Their Advantages, Applications of Robotics in Surgery – Neurosurgery, Orthopedic, Urology, Cardiovascular, Gynecology, Ophthalmic, Hair transplant. | | | | | | |
| **UNIT II** | **ADVANCED ROBOTIC SURGICAL SYSTEM** | | | **9** | | |
| Robot-Assisted Intraocular Surgery. Proposed Robotic Surgical System for Use in Ophthalmology - Feasibility of Cataract Surgery with the Proposed System. Deployable Laparoscopic Robotic Surgical System - AESOP®, ZEUS®, and da Vinci®: First Methods and Systems in Robotic Laparoscopy. | | | | | | |
| **UNIT III** | **INTRODUCTION TO REHABILITAION ROBOTICS** | | | **9** | | |
| Rehabilitation Robots- definition and scope, Basic Design Criteria - Therapeutic vs. assistive systems, Robot actuation and patient interaction, Exoskeletal vs. endeffector-based approach. Examples of Rehabilitation Robots. Biofeedback and Augmented Feedback Methods | | | | | | |
| **UNIT IV** | **ROBOT – AIDED ASSESMENT FOR REHABILITAION** | | | **9** | | |
| Control Strategies - Conventional controllers, Patient cooperative controllers, Bio-cooperative strategies. Robot-Aided Assessment - Mapping quantitative data to clinical scores, Automated spasticity assessment, Automated joint synergy assessment, Lower extremity assessments with the Lokomat, Upper extremity assessments with ARMin | | | | | | |
| **UNIT V** | **APPLICATION SURGICAL AND REHABILIATION ROBOTICS** | | | **9** | | |
| Applications of Smart Materials and Artificial Muscles in Robotic Surgery - Applications of Ionic Polymer Metal Composites (IPMCs), Feasibility of Kinesthetic Force Feedback and Integration of IPMCs. Clinical Outcomes for Rehabilitation Robots- Robot-aided Gait rehabilitation, Upper extremity rehabilitation. | | | | | | |
| **TOTAL: 45 PERIODS** | | | | | | |
| **Text Book:**   1. Mohsen Shahinpoor, “Robotic Surgery, Smart Materials, Robotics Structures and Artificial Muscles”, Pan Stanford Publishers, 2014. 2. R. Riener. “Rehabilitation Robotics”. Foundations and TrendsR in Robotics, 2012 | | | | | | |
| **Reference Book:**   1. Jacob Rosen, Blake Hannaford and Richard M. Satava , Editors, “Surgical Robotics Systems Applications and Visions”. Springer, 2011 2. Sashi S Kommu, “Rehabilitation Robotics”, Published by I-Tech Education and Publishing. | | | | | | |
| **Extensive Reading:**   * [http://www.springer.com/engineering/biomedical+engineering/book/978-1-4419-1125-4](http://www.springer.com/engineering/biomedical%2Bengineering/book/978-1-4419-1125-4). * Surgical Robotics: Systems Applications and Visions (by Rosen, Jacob, Hannaford, Blake, Satava,   Richard M. (Eds.))   * https://nptel.ac.in/courses/112104308 | | | | | | |