

## **ANNEXURE-A**

### **Syllabus of Pre-PhD Coursework Biomedical Engineering-2025**

| <b>S.No</b> | <b>Course Code</b> | <b>Subject title</b>                            |
|-------------|--------------------|-------------------------------------------------|
| 1           | PHD1001BM          | Research Methodology in Bio Medical Engineering |
| 2           | PHD1002BM          | Medical Assist Devices                          |
| 3           | PHD1003BM          | Bio Nano Technology                             |
| 4           | PHD1004BM          | Medical Device Regulations                      |
| 5           | PHD1005BM          | Medical Image Processing                        |



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**Department of Biomedical Engineering  
University College of Engineering (A)  
Osmania University, Hyderabad  
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|                       |                                                        |           |            |          |          |
|-----------------------|--------------------------------------------------------|-----------|------------|----------|----------|
| <b>PHD1001BM</b>      | <b>RESEARCH METHODOLOGY IN BIO MEDICAL ENGINEERING</b> |           |            |          |          |
| <b>Pre-requisites</b> |                                                        | <b>L</b>  | <b>T</b>   | <b>P</b> | <b>C</b> |
|                       |                                                        | 3         | -          | -        | 3        |
| <b>Evaluation</b>     | <b>SEE</b>                                             | 100 Marks | <b>CIE</b> | --       |          |

|                                                                      |                                                                                            |
|----------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| <b>Course Objectives :</b>                                           |                                                                                            |
| The course is taught with the objectives of enabling the student to: |                                                                                            |
| 1                                                                    | To learn the clinical research types, methodology and formulation.                         |
| 2                                                                    | To know the sources of literature, survey, review and quality journals.                    |
| 3                                                                    | To understand the research design for collection of research data, and standard databases. |
| 4                                                                    | To understand the research data analysis, writing of research report and grant proposal.   |

|                                                             |                                                                                                                |
|-------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| <b>Course Outcomes :</b>                                    |                                                                                                                |
| On completion of this course, the student will be able to : |                                                                                                                |
| <b>CO-1</b>                                                 | To understand the significance of pursuing research and defining research problem.                             |
| <b>CO-2</b>                                                 | Appreciate the importance and methodology of literature survey, and research design.                           |
| <b>CO-3</b>                                                 | Identify proper data and collect using appropriate tool.                                                       |
| <b>CO-4</b>                                                 | Compare and select the correct technique for the analysis of collected data.                                   |
| <b>CO-5</b>                                                 | Summarize the data analysis in the form of technical report and understand relevant standards and regulations. |

| Course outcome | Program Outcome |      |      |      |      |      |
|----------------|-----------------|------|------|------|------|------|
|                | PO-1            | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 |
| <b>CO-1</b>    | 1               | 1    | 3    | 2    | 1    | 2    |
| <b>CO-2</b>    | 3               | 1    | 2    | 3    | 2    | -    |
| <b>CO-3</b>    | 1               | 3    | 3    | 1    | 2    | 2    |
| <b>CO-4</b>    | 3               | 2    | 1    | 3    | 1    | 1    |
| <b>CO-5</b>    | 2               | 1    | 3    | 2    | 2    | 2    |

|                 |
|-----------------|
| <b>Unit – I</b> |
|-----------------|

**Introduction to Research Methodology:** Objectives and Motivation of Research, Types of Research, Research Approaches, Significance of Research, Research and Scientific Method, Importance of Research Methodology, Research Process, Criteria and characteristics of good research, challenges encountered by researchers and benefits of research.

**Defining the Research Problem:** Defining Research Problem, Problem Formulation, necessity of defining the Problem, Techniques involved in defining a Problem.

**Literature Review:** Importance of Literature review, sources of Information, Assessment of quality of Journals and research articles, Critical appraisal of Literature Review, Problem definition.

## Unit – II

**Research Design:** Meaning of Research Design, need of Research Design, Important concepts related to Research Design, Different Research Designs, Basic Principles of Experimental Design, Developing a Research Plan, Design of Experimental Set-up, Use of Standards and Codes.

**Research Tools:** Methods to search required information effectively, citation styles, reference management, software's (Zotero/ Mendeley /Endnote).

**Plagiarism:** plagiarism & self-plagiarism consequence of plagiarism, unintentional plagiarism, copyright infringement. Software's for detection of plagiarism (Turnitin/iThenticate).

## Unit – III

**Data Collection:** data types, collection of primary data, secondary data, Data organization, data validation, methods of data grouping, diagrammatic representation of data, Graphical representation of data. Sample design and population.

**Data Analysis:** Mathematical modeling: definition of model, types of models, mathematical model and modeling of engineering systems. Probability and its distribution, hypothesis testing, Test for significance: Chi-square, Student t-test, Regression modeling, ANOVA, F-test, Time Series analysis. Analysis of Data, Role of Statistics in Data Analysis, Parametric v/s non-Parametric methods, Descriptive Statistics. Concept of simulation and simulation methods etc.

## Unit – IV

**Research Report Writing:** Format of the research report, preparation of Synopsis in a effective manner, thesis writing, arrangements of chapters and finalization of chapter names. Ethics and moral issues related to research and publishing. References/Bibliography etc.

**Technical paper writing:** Layout of a research paper, impact factor of journals, research indicators (citations/h-index/i10 index/cite score, etc.), research profile building (Orcid-id/Google Scholar id/PubMed/Scopus id/etc.)

**Research Proposal Preparation:** Funding agencies in India and across the Globe, writing a research proposal, Writing Research Grant Proposal: Minor and Major Research proposals (UGC, DST and AICTE).

## Unit – V

**Advancements and scope in Research:** Types of Clinical Research, Research Approaches. Patient Information Sheet & Informed Consent Form, Standard Operating Procedures, Subject Selection, Recruitment & Retention, Clinical Trial Designs, Randomization & Blinding in Clinical Trials. Standard databases for medical data.

**Medical Ethics:** Moral Problems in Medical Ethics/Bioethics, Principles & Challenges in Medical Ethics, Ethical Guidelines for conducting clinical trials in Humans, Essential documents for conducting Clinical Research. Funding agencies for Medical Research.

**Suggested Reading:**

|   |                                                                                                                                                                        |
|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Peter Agger, Robert S. Stephenson, J. Michael Hasenkam, A Practical Guide to Biomedical Research: for the Aspiring Scientist, Springer international publishers, 2017. |
| 2 | Biomedical Research Methodology :Including Biostatistical Applications Paperback – 2011by Ranjan Das                                                                   |
| 3 | C.R Kothari, Research Methodology, Methods & Technique; New Age International Publishers, 2004                                                                         |
| 4 | Y.P. Agarwal, Statistical Methods: Concepts, Application and Computation, Sterling Publs., Pvt., Ltd., New Delhi, 2004                                                 |
| 5 | Richard C.Fries, <i>Handbook of medical device design</i> , Marcel Dekker Inc., 2001.                                                                                  |

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| PHD1002BM      |     | MEDICAL ASSISTIVE DEVICES |     |   |    |
|----------------|-----|---------------------------|-----|---|----|
| Pre-requisites |     | L                         | T   | P | C  |
|                |     | 3                         | -   | - | 3  |
| Evaluation     | SEE | 100 Marks                 | CIE |   | -- |

#### Course Objectives :

The course is taught with the objectives of enabling the student to:

|   |                                                                                                                                                              |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | To extend knowledge of the amputee, of lost and remaining functions affecting locomotion, and to collect information on the best possible medical treatment. |
| 2 | To improve fitting techniques and practices, including training, so that existing devices might be used with greater comfort and function.                   |
| 3 | To develop improved lower-extremity devices                                                                                                                  |

#### Course Outcomes :

On completion of this course, the student will be able to :

|      |                                                                                        |
|------|----------------------------------------------------------------------------------------|
| CO-1 | Apply fundamental knowledge of engineering in rehabilitation                           |
| CO-2 | Apply analytical skills to assess and evaluate the need of the end-user                |
| CO-3 | Develop self-learning initiatives and integrate learned knowledge for problem solving  |
| CO-4 | Understand the basics of robotics and apply their principles in developing prosthetics |
| CO-5 | Apply the knowledge of computers in solving rehabilitation problems                    |

| Course outcome | Program Outcome |      |      |      |      |      |
|----------------|-----------------|------|------|------|------|------|
|                | PO-1            | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 |
| CO-1           | 2               | 1    | 3    | 2    | 1    | 1    |
| CO-2           | 3               | 2    | 1    | 1    | 2    | -    |
| CO-3           | 2               | 2    | 2    | 3    | 2    | 1    |
| CO-4           | 1               | 3    | 1    | 2    | 1    | 1    |
| CO-5           | 1               | 1    | 2    | 3    | 2    | 3    |

#### Unit – I

Introduction to Rehabilitation Engineering, Measurement and analysis of human movement, Disability associated with aging in the workplace and their solutions, clinical practice of rehabilitation engineering.

## Unit – II

Assistive Technology, Seating Biomechanics and systems. Wheeled Mobility: Categories of Wheelchairs. Wheelchair Structure and Component Design. Ergonomics of Wheel chair propulsion. Power Wheelchair Electrical Systems. Control. Personal Transportation. Auxiliary devices and systems.

## Unit – III

Sensory augmentation and substitution: Visual system: Visual augmentation. Tactual vision substitution, Auditory vision substitution; Auditory system: Auditory augmentation. Cochlear implantation, Visual auditory substitution, Tactual auditory substitution, Tactual system: Tactual augmentation. Tactual substitution. Measurement tools and processes: fundamental principles, structure, function; performance and behavior. Subjective and objective measurement methods.

## Unit – IV

Rehabilitation Robotics, Major Limb Prosthetic Devices, Orthotic Devices, Types of orthotics and prosthetics, Intelligent prosthetic Knee, Prosthetic Hand, Controlled orthotics and prosthetics FES system, Restoration of Hand function, Restoration of standing and walking, Myo-electric Hand.

## Unit – V

Augmentative and Alternative communication technology, Computer applications in Rehabilitation Engineering, telecommunications, and Web Accessibility.

### Suggested Reading:

|   |                                                                                                                                                                                                         |
|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Robinson C.J., <i>Rehabilitation Engineering</i> , CRC Press, 1995.                                                                                                                                     |
| 2 | Ballabio E., et al., <i>Rehabilitation Technology</i> , IOS Press, 1993.                                                                                                                                |
| 3 | Rory A Cooper, Hisaichi Ohnabe, Douglas A. Hobson, <i>Series in medical physics and biomedical engineering: An introduction to rehabilitation engineering</i> , Taylor and Francis Group, London, 2007. |
| 4 | Joseph D. Bronzino <i>The biomedical engineering handbook -biomedical engineering fundamentals</i> , 3 <sup>rd</sup> Ed., CRC Press, Taylor & Francis Group, London, 2006.                              |



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|-----------------------|----------------------------|-----------|------------|----------|----------|
| <b>PHD1003BM</b>      | <b>BIO NANO TECHNOLOGY</b> |           |            |          |          |
| <b>Pre-requisites</b> | -                          | <b>L</b>  | <b>T</b>   | <b>P</b> | <b>C</b> |
|                       |                            | 3         | -          | -        | 3        |
| <b>Evaluation</b>     | <b>SEE</b>                 | 100 Marks | <b>CIE</b> | --       |          |

### Course Objectives :

The course is taught with the objectives of enabling the student to:

|   |                                                                                                              |
|---|--------------------------------------------------------------------------------------------------------------|
| 1 | To introduce the students to fabrication processes of MEMS and NEMS.                                         |
| 2 | To make the students learn the properties, characteristics, classification and applications of Nano devices. |
| 3 | To make the students understand the importance of Nano materials and their medical applications.             |

### Course Outcomes :

On completion of this course, the student will be able to :

|             |                                                                                                         |
|-------------|---------------------------------------------------------------------------------------------------------|
| <b>CO-1</b> | Explain the fabrication and applications of MEMS and NEMS                                               |
| <b>CO-2</b> | Compare the bottom-up and top-down approaches in nanomaterials fabrication.                             |
| <b>CO-3</b> | list the types of Carbon nanoparticles nanotubes and their fabrication                                  |
| <b>CO-4</b> | Describe the applications of Nanomaterials in cancer treatment, drug delivery and imaging applications. |
| <b>CO-5</b> | Explain the biosensor applications of Nanomaterials.                                                    |

| Course outcome | Program Outcome |      |      |      |      |      |
|----------------|-----------------|------|------|------|------|------|
|                | PO-1            | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 |
| <b>CO-1</b>    | 1               | 2    | 2    | 2    | 2    | 1    |
| <b>CO-2</b>    | 2               | 2    | 3    | 3    | 3    | 1    |
| <b>CO-3</b>    | -               | 1    | 2    | 2    | 2    | -    |
| <b>CO-4</b>    | 2               | 2    | 3    | 3    | 3    | 2    |
| <b>CO-5</b>    | 2               | 2    | 3    | 3    | 3    | 2    |

### Unit - I MEMS & NEMS:

Definition of MEMS, materials for MEMS (Silicon, Polymers and metals) and their properties, Deposition processes, Photolithography, and etching processes, Limitations of MEMS, NEMS, difference between MEMS and NEMS, properties of NEMS, fabrication processes, applications.

**Unit - II Introduction to Nanotechnology:** Nanomaterials, Fullerenes and carbon forms. Nanoparticles and Colloids, structure and bonding in nanoparticles, Nanomaterials fabrication by Bottom-up and Top down approaches, Classification of nanodevices based on the characteristics, Quantum dots and their properties.



**Unit - III Carbon nanotubes:**

Carbon nanoparticles, types of carbon nanotubes, single-walled, multi-walled, torus, nanobud, properties of carbon nanotubes, and synthesis by Arc discharge, laser ablation, chemical vapor deposition techniques

**Unit - IV Nanomedicine:**

Medical use of Nanomaterials, Drug delivery systems. Cancer treatment, Surgery. Drug tracking systems. Targeted drug delivery systems. Applications of Nanomaterials in Medical imaging. Neuro-electronic interfaces.

**Unit - V Bio molecular nanotechnology:**

Nanorobots and their application, nanosensors based on biomolecules such as DNA and proteins, nanoparticles for gene delivery systems, Computational genes, Biosensors for Glucose and measurement, Optical biosensors and their application.

**Suggested Reading:**

|   |                                                                                                                                                                                                       |
|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Lynn E. Foster, Foreword by George Allen, Foreword by Joe Lieberman, Nanotechnology: Science, Innovation, and Opportunity, Nanomedicine: Basic Capabilities, Vol. 1 by Robert A. Freitas Jr. 1999 Rev |
| 2 | Neelina Malsch, Biomedical nanotechnology by CRC press release, <i>Malsch TechnoValuation, Utrecht, The Netherlands</i>                                                                               |
| 3 | Gero Decher, Joseph B. Schlenoff, Multilayer Thin Films, Wiley-VCH Verlag GmbH & Co. KGaA, 2003                                                                                                       |
| 4 | David S. Goodsell, Bionanotechnology : Lessons from Nature, Wiley-Liss, 2004. Kenneth J. Klabunde, Nanoscale Materials in Chemistry., John Wiley & Sons, Inc., 2001                                   |



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| PHD1004BM      |     | MEDICAL DEVICE REGULATIONS |     |   |    |
|----------------|-----|----------------------------|-----|---|----|
| Pre-requisites |     | L                          | T   | P | C  |
|                |     | 3                          | -   | - | 3  |
| Evaluation     | SEE | 100 Marks                  | CIE |   | -- |

| Course Objectives :                                                  |                                                                                          |
|----------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| The course is taught with the objectives of enabling the student to: |                                                                                          |
| 1                                                                    | To understand the medical device classes and regulatory efforts                          |
| 2                                                                    | To understand the of national and international medical device regulations and standards |
| 3                                                                    | To know about the patents and intellectual property rights.                              |

| Course Outcomes :                                           |                                                                   |
|-------------------------------------------------------------|-------------------------------------------------------------------|
| On completion of this course, the student will be able to : |                                                                   |
| CO-1                                                        | Differentiate the medical devices under their respective classes. |
| CO-2                                                        | Design medical products using different methodologies             |
| CO-3                                                        | Deliver the rules of Indian Medical Device Regulations-2017       |
| CO-4                                                        | Understand the product safety and legal issues                    |
| CO-5                                                        | Apply the concepts in design of medical equipment.                |

| Course outcome | Program Outcome |      |      |      |      |      |
|----------------|-----------------|------|------|------|------|------|
|                | PO-1            | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 |
| CO-1           | 1               | 1    | 3    | 2    | 1    | 2    |
| CO-2           | 3               | 1    | 2    | 3    | 2    | -    |
| CO-3           | 1               | 3    | 3    | 1    | 2    | 2    |
| CO-4           | 3               | 2    | 1    | 3    | 1    | 1    |
| CO-5           | 2               | 1    | 3    | 2    | 2    | 2    |

| Unit - I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Definition of Testing, Parsing Test Requirements, Test Protocol, Test Methodology, Purpose Of The Test, Failure Definition, Determining Sample Size And Test Length, Types Of Testing. Analysis of Test Data- Failure Rate, Mean Time between Failure, Reliability, Confidence Level, Confidence Limits, Minimum Life, Graphical Analysis, Reliability And Liability- Negligence, Strict Liability, Breach Of Warranty, Defects, Failure To Warn Of Dangers, Plaintiff's Conduct, Defendants' Conduct, Defendant Related Issues, Manufacturers And Physicians Responsibilities, Accident reconstruction and forensics. |



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## Unit - II

Food And Drug Administration- History of Device Regulation, Device Classification, Registration And Listing, 510(K) Process, Declaration Of Conformance To A Recognized Standard, PMA Application , Investigational Device Exemptions, Good Laboratory Practices, Good Manufacturing Practices, Human Factors, Design Control, FDA And Software, Software Classification, FDA Inspection, Advice On Dealing With The FDA

Regulations And Standards- Definition OFA Medical Device, MDD, United States Domestic Standards, Rest Of The World Standards.

## Unit - III

Indian Medical Device Rules and Regulations-2017

Licensing Patents Copyrights And Trade Secrets Patents, Copyrights, Trademarks, Trade Secrets.

Manufacturing and quality control- GMP regulations, design for manufacturability, design for assembly, manufacturing process

## Unit - IV

Miscellaneous Issues- Learning From Failure, Design For Failure, Design For Convenience, Universal Design, Design For Assembly, Prevention Through Design, Design For The Environment, Poka-Yoke, Product Life Issues, Product Testing Issues.

Product Issues- Product Safety And Legal Issues, Accident Reconstruction And Forensics, Biomechanics And Traffic Accident Investigations.

Professional Issues- BME – Related Professional Societies, Standards Setting Groups, Professional Engineering Licensure, Rules Of Professional Conduct, Codes Of Ethics, Forensics And Consulting, Continuing Education.

## Unit - V

Design of Case studies: Multidetector brain scanning system development, testing of anesthetists, apnea detection system, cancer clinic charting, EKG analysis techniques & module.

## Suggested Reading:

- |   |                                                                             |
|---|-----------------------------------------------------------------------------|
| 1 | Design of Biomedical Devices and systems ( Paul H. King & Richard C. Fries) |
|---|-----------------------------------------------------------------------------|

| PHD1005BM      |     | MEDICAL IMAGE PROCESSING |     |   |     |
|----------------|-----|--------------------------|-----|---|-----|
| Pre-requisites |     | L                        | T   | P | C   |
|                |     | 3                        | -   | - | 3   |
| Evaluation     | SEE | 100 Marks                | CIE |   | --- |

### Course Objectives :

The course is taught with the objectives of enabling the student to:

|   |                                                                                              |
|---|----------------------------------------------------------------------------------------------|
| 1 | To make the students have clear understanding on the principles of Digital Image processing. |
| 2 | To make students learn and understand image enhancement in spatial and frequency domain.     |
| 3 | To familiarize the students with the image restoration and segmentation algorithms.          |

### Course Outcomes :

On completion of this course, the student will be able to :

|      |                                                                                                                                        |
|------|----------------------------------------------------------------------------------------------------------------------------------------|
| CO-1 | Good understanding of the mathematical foundations for digital manipulation of images: image acquisition; preprocessing; segmentation. |
| CO-2 | Comprehend the principles of image preprocessing.                                                                                      |
| CO-3 | Perceive the governing principles of image segmentation.                                                                               |
| CO-4 | Evaluate the image restoration and registration methods.                                                                               |
| CO-5 | Realize how to implement morphological principles to the medical images.                                                               |

| Course outcome | Program Outcome |      |      |      |      |      |
|----------------|-----------------|------|------|------|------|------|
|                | PO-1            | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 |
| CO-1           | 2               | 1    | 3    | 2    | 1    | 1    |
| CO-2           | 3               | 2    | 1    | 1    | 2    | -    |
| CO-3           | 2               | 2    | 2    | 3    | 2    | 1    |
| CO-4           | 1               | 3    | 1    | 2    | 1    | 1    |
| CO-5           | 1               | 1    | 2    | 3    | 2    | 3    |

### Unit -- I

Digitized image functions, Dirac distributions, convolution, Fourier transform, Images as linear system. Image digitization, sampling, Quantization, color images. Digital image properties, Metric and topological properties, Histogram visual perception, Image quality, Noise. Data structures for image analysis, data representation, traditional and hierarchical data structures.



**Unit - II**

Image Enhancement. Contrast manipulation, histogram equalization, Laplacian derivatives, Sobel and Kirsch operators, rank operators –textural analysis. Image pre processing – pixel brightness transformations, Geometric transformations, local pre processing, Image restoration. Imaging filters.

**Unit – III**

Thresholding and Segmentation. Detection methods, optimal thresholding, multi-spectral thresholding. Edge based segmentation, Region based segmentation, Matching, Advanced optimal border and surface detection approaches.

**Unit – IV**

Restoration. Deterministic, geometric linear filtration, inverse filtering, power spectrum equalization, stochastic. Wiener filtering. Registration, anatomy based, object based, scene based.

**Unit – V**

Mathematical morphology. Basic morphological concepts, Morphological principles: Binary dilation and erosion, Gray scale dilation and erosion, skeletons and object marking, granulometry, Morphological segmentation and water sheds.

**Suggested Reading:**

|   |                                                                                                                                                          |
|---|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | John C Russ, <i>The image processing handbook</i> , CRC and IEEE press –1999.                                                                            |
| 2 | Milan Sonka, Vaclav Hlavac, Roger Boyle, <i>Image processing, analysis and machine vision</i> 2 <sup>nd</sup> edition, Brooks/Cole publishing Co., 1999. |
| 3 | Jayaram, Kudupa and Gabor, T Herman, <i>3D imaging in medicine</i> , 2 <sup>nd</sup> edition, CRC 2000.                                                  |
| 4 | Craig A. Hindley, <i>Practical image processing in C</i> , John Wiley and Sons 1991.                                                                     |



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