COEP Technological University Pune

(A Unitary Public University of Govt. of Maharashtra)

School of Engineering and Technology

Curriculum Structure & Detailed Syllabus

M. Tech. In AI in Healthcare

Instrumentation and Control Engineering

(Effective from: A.Y. 2026-27)

Program Educational Objectives (PEOs)

After the completion of the program,

I. Student will be employable in the diversified sectors of the industry, government organizations, public sector and research organizations.

II. Student will pursue higher education in engineering or other fields of their interests, at institutes of repute and high ranking.

III. Student will demonstrate effective communication, lifelong learning ability, integrity, teamwork, leadership qualities, concern to environment and commitment to safety, health, legal and cultural issues in the fields they choose to pursue.

Program Outcomes (POs):

Engineering Graduate will be able to:

PO1: Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problem.

PO2: Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural science, and engineering sciences.

PO3: Design/Development Solution: Design solution for complex engineering problems and design system component or process that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, social and environmental conditions.

PO4: Conduct Investigation of Complex Problem: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusion.

PO5: Method, Tool Usage: Create, select and apply appropriately technique, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with understanding the limitation.

PO6: The Engineer and Society: Apply reasoning informed by the contextual knowledge to access societal health, safety, legal and cultural and consequent responsibility relevant to the professional engineering practice.

PO7: Environment and Sustainability: Understand the impact of the professional engineering solution in societal and environmental context, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principle and commitment to professional ethics and responsibilities and norms of the engineering practices.

PO9: Individual and Team Work: Function effectively as an individual, and as the member or leader in diverse team and multidisciplinary setting.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, and being able to comprehend and write effective reports and design documentation and effective presentation and give and receive clear instructions.

PO11: Project management and Finance: Demonstrate knowledge & understanding of the engineering and management principles and apply these to one's work, as the member and the leader in a team to manage projects and in multidisciplinary environment.

PO12: Lifelong Learning: Recognize the need for and have the preparation and ability to engage in independent and lifelong learning in broadest context of technological change.

M. Tech. In AI in Healthcare

Instrumentation and Control Engineering

List of Abbreviations

Abbreviation	Title	No of Courses	Credits	% of Credits
BS	Basic Science Course			
ESC	Engineering Science Course			
PCC	Programme Core Course (PCC)			
PEC	Programme Elective Course (PEC)			
OE/SE	Open/School Elective (OE/SE) other than particular program			
MDM	Multidisciplinary Minor (MDM)			
VSEC	Vocational and Skill Enhancement Course (VSEC)			
HSMC	Humanities Social Science and Management			
IKS	Indian Knowledge System (IKS)			
VEC	Value Education Course (VEC)			
RM	Research Methodology (RM)			
--	Internship			
--	Project			
CEA	Community Engagement Activity (CEA)/Field Project			
CCA	Co-curricular & Extracurricular Activities (CCA)			
	Total			

M. Tech. In AI in Healthcare

Instrumentation and Control Engineering

Semester -I

Sr. No	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1.	PSMC	*AIHC-25001*	Mathematics for AI & ML	3	1	0	1	4	30	20	50	-	-
2.	PSBC	*AIHC-25002*	Anatomy & Physiology for Engineers	3	0	0	1	3	30	20	50	-	-
3.	PCC	*AIHC-25003*	Medical Data Acquisition and signal processing	3	1	0	1	4	30	20	50	-	-
4.	PCC	*AIHC-25001*	Introduction to Artificial Intelligence (MOOC)	3	0	0	0	3	30	20	50	-	-
5	LC	*AIHC-25004*	Computing Techniques Lab	0	0	6	0	3		50		-	50
8.	PEC		**Program Specific Elective –I**	3	0	0	1	3	30	20	50	-	-
9.	VSEC	*SET-25003*	Seminar	0	0	2	0	1	-	-	50	-	
10.	VSEC	*SET-25003*	Technical Writing	0	0	2	0	1	-	-	50	-	-
11.	MLC	*SET-25001*	Research Methodology	3	0	0	1	3	-	-	-	-	-
				18	2	10	05		-	-	-	-	-
			Total Credits			**25**							

Program Specific Elective –I

1. Biomaterials
2. Introduction to Medical Software/Medical Algorithms
3. Biomedical Devices and systems

Semester -II

Sr. No	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1.	OE		Open Elective	3	0	0		3	-	-	-	-	-
2.	PCC	*AIHC-25006*	Introduction to Machine Learning and Deep Learning	3	0	0		3	30	20	50	-	-
3.	PCC	*AIHC-25007*	Medical Image Analysis	3	0	0		3	30	20	50	-	-
4.	PCC	*AIHC-25008*	Wearable Devices and Remote Monitoring	3	0	0		3	30	20	50	-	-
5.	LC	*AIHC-25009*	Health Informatics and Data Analytics Lab	0	0	2		1	-	50	-	-	50
6.	LC	*AIHC-25010*	Predictive Medical Image Analysis Lab	0	0	2		1	-	50	-	-	50
7.	LC	*AIHC-25011*	Wearable and Remote Monitoring Lab	0	0	2		1	-	50	-	-	50
8.	PEC		Program Specific Elective –II	3	0	0		3	30	20	50	-	-
9.	PEC		Program Specific Elective –III	3	0	0		3	30	20	50	-	-
10.	AEC		Technical Communication Skills	1	0	2		2	-	-	-	-	-
11.	CCA		Liberal Learning Course	1	0	0		1	-	-	-	-	-
				20	0	8			-	-	-	-	
			Total Credits	**24**									

List of Program Specific Elective –II & III

1. Healthcare informatics, privacy and security
2. Natural Language Processing in Healthcare
3. Bio-Implants
4. Robotics in surgery
5. Computer Vision
6. Embedded System for Machine Learning and Deep Learning

Thesis Project: Preliminary document to be submitted on the chosen project covering Requirement Specifications, Design and resource estimation, existing scenario etc. The document needs to be submitted to the nominated project guide for approval. High value is attached to originality in design aspects. This stage carries 30 percent of the project credit. The balance will be awarded in the second year on project completion and report submission. The degree will be awarded only upon earning minimum credit hours and upon successful completion of the project. The successful completion of the project is the essence of the course. The project topic can be chosen by the student with assistance from the internal guide or an external co-guide.

Semester -III

Sr. No	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1.	VSEC		Dissertation Phase – I	--	--	22	12	11	-	-	-	-	-
2.	SLC		Massive Open Online Course -I	3	--	--	1	3	-	-	-	-	-
3.	SLC		Massive Open Online Course –II	3	--	--	1	3	-	-	-	-	-
4.	OJT		Internship	--	--	--	--	3	-	-	-	-	-
Total Hrs.				6	--	22	14	20	-	-	-	-	-
Total Credits				**20**									

Thesis Project

- Independent research on topics such as AI for diagnostics, predictive models, or surgical robotics that was approved at the end of First year, second semester will continue

Semester -IV

Sr. No	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1	VSEC		Dissertation Phase – II	--	--	22	12	11	-	-	-	-	-
Total Hrs.				--	--	22	12	11	-	-	-	-	-
Total				**22**									

Semester - I

Mathematics for AI & ML						
Course Code	AIHC-25001		**Examination Scheme**			
Teaching Scheme	3-1-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	4		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Analyze: Analyze and model data using appropriate probability distributions and statistical models
2. Apply: Apply concepts of linear algebra, calculus, and trigonometry to solve engineering problems
3. Interpret: Interpret and summarize data using descriptive statistical measures
4. Integrate: Integrate mathematical and statistical tools to address real-world problems in data science and healthcare technology

Course Content:

Linear Algebra; Calculus; Introduction to Statistics and Probability; Descriptive statistics; Inferential statistics; Probability distributions; Hypothesis testing; Statistical modeling; Trigonometry; Tomographic reconstruction; Fourier Transform

Reference Books:

[1]	Introductory Statistics (10th Edition) -, by Neil A. Weiss published by Pearson
[2]	Introductory Statistics (4th Edition) - by Sheldon M. Ross
[3]	Advanced Trigonometry – by C V Durell and A Robson
[4]	Fundamentals of Computerized tomography- by Gabor T Herman
[5]	Fourier Analysis : An Introduction- by Elias M Stein

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Anatomy and Physiology for Engineers						
Course Code	AIHC-25002		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Describe human body structure.
2. Understand working of different physiological systems of human body.
3. Explain the functioning of the human body system.
4. Understand biological control and feedback mechanism.
5. Apply knowledge of human anatomy and physiology to solve different biomedical research problems.

Introduction to cell, Blood:

Characteristics of blood, physiology of blood clotting, biochemical cycle

Heart (Circulatory System)-

Anatomy of heart and blood vessels, origin and conduction of heartbeat, cardiac cycle, electrocardiogram, blood pressure, control of cardiac cycle.

Respiratory System-

Anatomy of respiratory system, physiology of respiration in the alveolar and tissue capillaries, control of respiration.

Digestive system:

Anatomy of digestive system, nerve and blood supply, physiology of digestion.

Kidney and Urinary system -

Anatomy of urinary system and kidney, physiology of water and electrolyte balance, acid-base regulation.

Muscle Tissues -

Anatomy, types of muscles, physiology of muscle contraction, generation of action potential, rhythmicity of cardiac muscle contraction, properties of skeletal and Cardiac muscles.

Nervous system -

Neuron, anatomy and function of different parts of brain, spinal cord, autonomic nervous system, Sensory system - Visual, auditory, Vestibular Endocrine system- pituitary, thyroid, parathyroid, adrenal, pancreas, Biological control and feed-back mechanism, clinical and technological implications

Reference Books:

[1] "Ross & Wilson Anatomy and Physiology in Health and Illness", by Allison Grant, Anne Waugh, and Kathleen J. W. Wilson

[2] Anatomy and Physiology for Engineers- A handbook for biomedical engineers- by P. Manimegalal

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Medical Data Acquisition and Signal Processing						
Course Code	AIHC-25003		**Examination Scheme**			
Teaching Scheme	3-1-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	4		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Apply appropriate methods for medical data collection, storage, cleaning, and integration.
2. Understand and implement healthcare data standards such as HL7, ICD, SNOMED, and LOINC.
3. Analyze big data technologies in the context of healthcare applications.
4. Evaluate case studies to understand real-world applications of medical data analytics in clinical and administrative settings.

Course Content:

Introduction to Medical Data; Sources of Medical Data; Data Collection and Management; Medical Data Standards and Privacy; Healthcare data standards (HL7, ICD, SNOMED, LOINC); Privacy laws and regulations: HIPAA, GDPR, and their impact on data management; De-identification, data anonymization, and consent; Medical Data Mining; Big Data in Healthcare; Applications and Case Studies

Reference Books:

[1] Hands-on on Healthcare data : Taming the complexity of real world data- by – Andrew Nguyen

[2] Healthcare Data Analytics -by Chandan K Reddy & Charu A Agrawal

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Introduction to Artificial Intelligence

Course Code	AIHC-25005		**Examination Scheme**			
Teaching Scheme	3-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Model real-world problems as search problems
2. Apply uninformed and heuristic search algorithms
3. Formulate and solve problems using constraint satisfaction techniques.
4. Represent knowledge using propositional logic and apply satisfiability techniques
5. Apply principles of decision theory and Markov Decision Processes for sequential decision-making.

Course Content:

Introduction: Philosophy of AI, Definitions; Modeling a Problem as Search Problem, Uninformed Search; Heuristic Search, Domain Relaxations; Local Search, Genetic Algorithms; Adversarial Search; Constraint Satisfaction; Propositional Logic & Satisfiability; Uncertainty in AI, Bayesian Networks; Bayesian Networks Learning & Inference, Decision Theory; Markov Decision Processes; Reinforcement Learning Introduction to Deep Learning & Deep RL

Reference Books:

[1] Stuart Russell & Peter Norvig, Artificial Intelligence: A Modern Approach, Prentice-Hall, Third Edition (2009)

[2] Ian Goodfellow, Yoshua Bengio & Aaron Courville, Deep Learning, MIT Press (2016).

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Computing Techniques Lab

Course Code	AIHC-25004		**Examination Scheme**			
Teaching Scheme	0-0-6-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Apply knowledge of different numerical methods to solve real world problems using python.
2. Solve ordinary differential equations (ODEs) using basic and advanced numerical methods including implicit schemes and higher-order methods.
3. Analyze systems of ODEs, stiff equations, and use Fourier transforms for frequency-domain analysis.
4. Apply finite difference (FD) methods for solving various PDEs and compare with spectral methods.

Course Content:

Handson 1: Python variables, Python arrays

Handson 2: Python Control Structure, Functions, Programming style

Handson 3: Plotting, Data input/output, Error analysis and nondimensionalization

Handson 4: Lagrange Interpolation, Splines

Handson 5: Numerical Integration: Newton Cotes, Gaussian quadrature, Multidimensional and misc integration

Handson 6: Differentiation, ODE solvers: Euler method, ODEs: Implicit schemes

Handson 7: ODEs: Higher-order method, ODEs: System of eqns, Stiff equations, Fourier Transforms

Handson 8: Spectral method (PDE solvers): Diffusion equation, Spectral method: Wave and Burger eqn solver, Spectral: Navier-Stokes eqn solver, Spectral: Schrodinger eqn solver

Handson 9: Finite Difference (FD) (PDE solvers): Diffusion equation, FD method: Wave and Burger eqn solver, FD Method: Navier-Stokes eqn solver, FD Method: Schrodinger eqn solver

Handson 10: Solving Nonlinear Equations (Root finders), Boundary value problems (Shooting method), Eigenvalue solver for diff equations

Handson 11: Laplace equation solvers, Laplace equation solvers, Poisson equation solvers

Handson 12: Linear algebra: Solution of linear equations, Eigenvalues and eigenvectors, Intro to Monte Carlo method

Reference Books:

[1] Practical Numerical Computing Using Python : Scientific and Engineering Applications (2021)

[2] Mark Newmann: Computational Physics with Python, 2nd Ed.

[3] J. M. Stewart: Python for Scientists, Cambridge U. Press (2014)

[4] J. H. Ferziger, Numerical Methods for Engineering Applications, John Wiley & Sons (in TB section).

[5] M. Lutz, Learning Python 5th Edition, O'Reilly Media (2013)

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Biomaterials

Course Code	AIHC(PE)-25001		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: --	ESE: --	--

Course Outcomes: Students will be able to:

1. Identify and classify various materials used in medicine, including metals, polymers, hydrogels, and biodegradable materials.
2. Understand mechanisms of material degradation in biological environments, particularly for polymers, metals, and ceramics.
3. Apply knowledge of biomaterials to various medical and clinical applications such as cardiovascular devices, dental implants, orthopedic devices, drug delivery systems, and biosensors.
4. Analyze the structure and function of biologically functional materials, ceramics, natural materials, composites, thin films, and nano-biomaterials in medical applications.
5. Assess the biocompatibility and performance of biomaterials in relation to specific biomedical applications.

Course Content:

Properties of Materials: Bulk properties and Surface properties of Materials. Characterization methods of surface properties of Biomaterials

Materials Used In Medicine: Metals; Polymers; Hydrogels; Bioresorbable and Biodegradable Materials.

Materials Used in Medicine: Biologically Functional Materials; Ceramics; Natural materials; Composites, thin films, grafts and coatings; Pyrolytic Carbon for long-term medical Implants; Porous materials; Nano biomaterials.

Host Reactions to Biomaterials: Inflammation; Wound healing and the Foreign body response; Systemic toxicity and Hypersensitivity; Blood coagulation and Blood-materials Interactions; Tumorigenesis. Degradation of Materials in Biological Environment: Degradation of Polymers, Metals and Ceramics.

Application of Biomaterials Cardiovascular Applications; Dental implants; Adhesives and Sealants; Opthalmologic Applications; Orthopedic Applications; Drug Delivery System; Sutures; Bioelectrodes; Biomedical Sensors and Biosensors

Reference Books:

[1] Ratner, Buddy D., et al. *Biomaterials Science: An Introduction to Materials in Medicine*. 2nd ed. Burlington, MA: Academic Press, 2004. ISBN: 9780125824637.

[2] Bronzino, J. D. (2000). The Biomedical Engineering Handbook. Germany: CRC Press

[3] Biomaterials: Principles and Applications- by Joon B Park & Joseph D Bronzino

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Introduction to Medical Software/ Medical Algorithms						
Course Code	AIHC(PE)-25002		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: --	ESE: --	--

Course Outcomes: Students will be able to:

1. Interpret key medical software regulations and standards, including those from CDSCO, SaMD, FDA, and IMDRF.
2. Understand and apply the stages of the Software Development Life Cycle (SDLC) specific to medical applications.
3. Identify and define user needs and system requirements for safe and effective medical software.
4. Design software architecture and apply usability engineering principles in healthcare applications.

Course Content:

Introduction to Medical Software and Digital Health; Medical Software Regulation (CDSCO, SaMD, FDA and IMDRF); The Healthcare Environment (EHR, PACS, Data Privacy, and Cybersecurity); Quality and Risk Management; Software Development Life Cycle; User Needs & System Requirements; Software Architecture Design and Usability Engineering; Construction and Testing; Software Validation, Deployment, Maintenance and Retirement; Role of Artificial Intelligence in Medical software; Business and Management challenges; Case Studies

Reference Books:

[1] Medical Device Software: Verification, Validation, and Compliance *by* David A. Vogel; Artech House publisher

[2] Handbook of Digital Health: Technologies, Applications, and Challenges *by* Homero Rivas, Katarzyna Wac; Springer

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[5] To measure CO5, some questions may be based on self-study topics and comprehension of unseen passages.

Biomedical Devices and Systems						
Course Code	AIHC(PE)-25003		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: --	ESE: --	--

Course Outcomes: Students will be able to:

1. Describe the operation and clinical applications of therapeutic and life-saving medical devices.
2. Analyze the working principles and applications of respiratory instrumentation used in clinical settings.
3. Evaluate electrical safety standards and related instrumentation in the context of patient and operator protection.
4. Understand the operation of common clinical laboratory instruments and their role in medical diagnostics.

Course Content:

Cardiovascular Devices; Therapeutic devices; Life-saving devices; Respiratory Instrumentation; Clinical Laboratory Instruments; Operation room instruments; Electrical safety and related instruments; Biomechanical Instrumentation; Instrumentation for Medical Imaging

Reference Books:

[1]	Leslie Cromwell, Fred J. Weibull, Erich A. Pfeiffer, "Biomedical Instrumentation and Measurements", Pearson Education, 2nd ed. 1980.
[2]	R. S. Khandpur, "Handbook of Biomedical Instrumentation", TMH, 2nd ed., 2008
[3]	Vander, Shermen, "Human Physiology" – The Mechanism of Body Functions", TMH, 13th ed., 2013.
[4]	Tompkins, "Biomedical Digital Signal Processing", PHI, 5th ed., 2010
[5]	John G Webster, "Encyclopedia of Medical Devices and Instruments", Wiley Publications, 1988.
[6]	M. Arumugam, "Biomedical Instrumentation", Amerada Publishers, 2nd ed., 1992
[7]	Carr and Brown "Introduction to Biomedical Equipment Technology", Pearson LPE, 4th ed., 2001.
[8]	Richard Aston, "Principles of Biomedical Instrumentation and Measurement", Maxwell Macmillan, International ed., 1990.
[9]	John G. Webster, "Medical Instrumentation Application and Design", John Wiley& Sons Pvt. Ltd, 3rd ed., 2009

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Seminar						
Course Code			**Examination Scheme**			
Teaching Scheme	0-0-2-0		**Theory**	TA: --	MSE: --	ESE: 50
Credits	1		**Laboratory**	CIE: --	ESE: --	--
Course Outcomes: Students will be able to:						
1. Identify a real-world problem and formulate it as a machine learning or AI task. 2. Design and develop a small-scale AI/ML-based solution using appropriate algorithms and methodologies. 3. Implement the solution using relevant programming languages, tools, and frameworks. 4. Evaluate the performance of the developed model using suitable metrics and validation techniques. 5. Present the project findings, demonstrating problem-solving and critical thinking skills						
Course Content:						
Each student is required to deliver a seminar in first semester on state of art of the topic of his/her own choice. The topic of the seminar should be out of the syllabus and relevant to the latest trends in automation. The student is expected to submit the seminar report in standard format approved by the guide.						

Technical Writing						
Course Code			**Examination Scheme**			
Teaching Scheme	0-0-2-0		**Theory**	TA: --	MSE: --	ESE: 50
Credits	1		**Laboratory**	CIE: --	ESE: --	--
Course Content:						
Modes of Technical Writings: Reports, Technical papers, book chapters, Manuals, Posters. Structure of a technical document. Copyright issues in technical writing: existing laws, open sources, permission procedure. How to write a good technical paper?, Proper procedure in citing already published works, Referencing styles. Common mistakes of English in scientific documents. Proper way of writing and citing equations. Proper use of figures and tables. Writing a good review paper. Writing of abstract, synopsis, cover letters, responses, discussion and keywords. Making title page, writing mathematical equations, including graphics, making tables and writing references using LaTex/ MiKTeX.						

Semester - II

Introduction to Machin Learning and Deep Learning						
Course Code	AIHC-25006		**Examination Scheme**			
Teaching Scheme	3-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Understand the foundations of statistical decision theory, including regression, classification, and the bias-variance tradeoff.
2. Apply various linear regression techniques, including multivariate regression, subset selection, shrinkage methods, and dimensionality reduction approaches like PCR and PLS.
3. Implement linear classification techniques such as logistic regression, linear discriminant analysis, and support vector machines.
4. Understand and build early neural network models including perceptron and multilayer perceptron's, using backpropagation and parameter estimation techniques (MLE, MAP, Bayesian).

Introduction:

Statistical Decision Theory - Regression, Classification, Bias Variance
Linear Regression, Multivariate Regression, Subset Selection, Shrinkage Methods, Principal Component Regression, Partial Least squares
Linear Classification, Logistic Regression, Linear Discriminant Analysis Perceptron, Support Vector Machines

Neural Networks -

Introduction, Early Models, Perceptron Learning, Backpropagation, Initialization, Training & Validation, Parameter Estimation - MLE, MAP, Bayesian Estimation Decision Trees, Regression Trees, Stopping Criterion & Pruning loss functions, Categorical Attributes, Multiway Splits, Missing Values, Decision Trees - Instability Evaluation Measures Bootstrapping & Cross Validation, Class Evaluation Measures, ROC curve, MDL, Ensemble Methods - Bagging, Committee Machines and Stacking, Boosting Gradient Boosting, Random Forests, Multi-class Classification, Naive Bayes, Bayesian Networks
Undirected Graphical Models, HMM, Variable Elimination, Belief Propagation
Partitional Clustering, Hierarchical Clustering, Birch Algorithm, CURE Algorithm, Density-based Clustering Gaussian Mixture Models, Expectation Maximization
Introduction to Deep Learning, Bayesian Learning, Decision Surfaces Linear Classifiers, Linear Machines with Hinge Loss Optimization Techniques, Gradient Descent, Batch Optimization
Introduction to Neural Network, Multilayer Perceptron, Back Propagation Learning Unsupervised Learning with Deep Network, Autoencoders Convolutional Neural Network, Building blocks of CNN, Transfer Learning Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam
Effective training in Deep Net- early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization
Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network, Fully Connected CNN etc.
Classical Supervised Tasks with Deep Learning, Image Denoising, Semantic Segmentation, Object Detection etc.
LSTM Networks
Generative Modeling with DL, Variational Autoencoder, Generative Adversarial Network Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam

Reference Books:

[1]	The Elements of Statistical Learning, by Trevor Hastie, Robert Tibshirani, Jerome H. Friedman
[2]	Deep Learning- Ian Goodfelllow, Yoshua Benjio, Aaron Courville, The MIT Press
[3]	Pattern Recognition and Machine Learning, by Christopher Bishop

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Medical Image Analysis

Course Code	AIHC-25007		**Examination Scheme**			
Teaching Scheme	3-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Understand the fundamentals and physics behind various medical imaging techniques and image acquisition processes.
2. Apply basic image processing techniques to enhance and analyze medical images.
3. Implement rigid and non-rigid image registration methods and evaluate their applications in medical imaging.
4. Develop and apply deep learning models, such as 3D convolutional neural networks, for complex medical image analysis tasks.

Course Content:

Introduction to medical imaging; Physics of Medical Imaging Techniques; Medical Image Acquisition; Basic image processing techniques; Image registration – 1- Rigid models; Image registration – 2- Non-Rigid models; Image registration – 3- Application and demonstration; Image segmentation - Statistical shape model; Image segmentation – PDE based methods; Image segmentation – application and demonstration; Computer Aided Diagnosis – Case Study 1; Computer Aided Diagnosis – Case Study 2; Deep Learning for Medical image analysis – 3D Convolutional Neural Networks; Deep Learning for Medical image analysis – Generative models for synthetic data

Reference Books:

[1] Rangaraj M. Rangayyan, ―Biomedical Image Analysis‖ CRC Press, 2005

[2] Rafael G. Gonzaleg, Kichard E. Wood, ―Digital Image Processing‖ Pearson Education, LPE

[3] Bishop, C., ―Pattern Recognition and Machine Learning:,‖ Berlin: Springer-Verlag, 2006

[4] Thomas S. Curry, Jumer E. Dowdey, Robert C. Murry, ―Christensen‘s physics of Diagnostic Radiology‖, Lippincott Williams & Wilkins, ISBN -10 0812113101

[5] John G. Webster, ―Encyclopedia of Medical Devices and Instrumentation Vol. I , II, III, IV‖,Wiley Publication.

[6] KavyanNajarian and Robert Splerstor,‖ Biomedical signals and Image processing‖, CRC – Taylor and Francis, New York, 2006

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Wearable Devices and Remote Monitoring

Course Code	AIHC-25008		**Examination Scheme**			
Teaching Scheme	3-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Analyze the principles and applications of wearable haptic and tactile devices in healthcare.
2. Understand the design, challenges, and applications of chemical and biochemical wearable sensors.
3. Describe flexible electronics and energy harvesting systems, including low-power circuit design for biopotential sensing and energy harvesting techniques from human body and ambient sources.
4. Apply knowledge of wearable sensors to monitor physical and physiological parameters related to cardiovascular, neurological, and gastrointestinal diseases.
5. Evaluate assistive wearable technologies and devices designed for individuals with severe paralysis, such as tongue drive systems.
6. Understand the concepts and technologies behind remote patient monitoring and telehealth, including practical applications and case studies.

Course Content:

Introduction to Wearable sensors – Attributes of wearables – Meta-wearable – Challenges and opportunities – Future of wearables – Social interpretation of Aesthetics – Case study – Google glass – Wearable haptics – Need for wearable haptic devices – Categories of wearable haptic and tactile display – Wearable Sensors – Chemical and Biochemical sensors – System design – Challenges in chemical biochemical sensing – Applications

Flexible Electronics and Energy Harvesting Systems – Thin-film transistors – Low-power Integrated Circuit design for biopotential sensing – Analog circuit design techniques – Lowpower design for ADCs – Digital circuit design techniques – Architectural design for low power biopotential acquisition – Practical considerations – Energy harvesting from human body – Temperature gradient – Foot motion – Wireless energy transmission – Energy harvesting from light and RF energy – Energy and power consumption issues – Future considerations

Monitoring Physical and Physiological Parameters – Wearable sensors for physiological signal measurement – Physical measurement – cardiovascular diseases – Neurological diseases – Gastrointestinal diseases – Wearable and non-invasive assistive technologies – Assistive devices for individuals with severe paralysis – Wearable tongue drive system – Dual-mode tongue drive system.

Introduction to Remote patient monitoring system, Concept of telehealth, Remote patient monitoring devices, Case studies and applications

Reference Books:

[1]	Edward Sazonov, Michael R Neuman, Wearable Sensors: Fundamentals, Implementation and Applications, Academic Press, USA, 2014.
[2]	Tom Bruno, Wearable Technology: Smart Watches to Google Glass for Libraries, Rowman & Littlefield Publishers, Lanham, Maryland, 2015.
[3]	Raymond Tong, Wearable Technology in Medicine and Health Care, Academic Press, USA, 2018.
[4]	Haider Raad, The Wearable Technology Handbook, United Scholars Publication, USA, 2017.

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Health Informatics and data analytics Laboratory						
Course Code	AIHC-25009		**Examination Scheme**			
Teaching Scheme	0-0-2		**Theory**	TA: 50	MSE:	ESE:
Credits	1		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Implement and evaluate various regression models such as simple linear, multiple linear, polynomial regression, support vector regression, and random forest regression.
2. Apply classification algorithms including logistic regression, SVM, KNN, Naive Bayes, decision trees, and random forests, and evaluate their performance.
3. Understand and implement association rule learning algorithms like Apriori and Eclat for pattern mining.
4. Apply basic reinforcement learning techniques such as Upper Confidence Bound (UCB) and Thompson Sampling for decision-making problems.

Handson 1:

Introduction to python for Machine Learning, Data Pre-processing using python

Handson 2:

Regression analysis using python (Simple linear, Multiple linear, Polynomial, Support Vector, Random Forest)

Handson 3:

Evaluation of regression model and selection of regression model

Handson 4:

Classification using python (Logistic regression, SVM, KNN, Neive based, Decision tree, Random Forest)

Handson 5:

Evaluation of classification model and selection of classification model

Handson 6:

Clustering using python (K-means, Hierarchical clustering)

Handson 7:

Evaluation of clustering model and selection of model

Handson 8:

Association Rule Learning: Apriori, Eclat

Handson 9:

Reinforcement Learning: Upper Confidence Bound, Thompson Sampling
Write course outcomes

Reference Books:

[1] "Biomedical Informatics: Computer Applications in Health Care and Biomedicine" *By Edward H. Shortliffe & James J. Cimino*

[2] "Health Informatics: Practical Guide" *By Robert E. Hoyt & Ann K. Yoshihashi*

[3] "Machine Learning for Healthcare" *By Kevin Franks & Saeed Hassanpour*

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Wearable Devices and Remote Monitoring Laboratory						
Course Code	AIHC-25011		**Examination Scheme**			
Teaching Scheme	0-0-2		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	1		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Analyze the principles and applications of wearable haptic and tactile devices in healthcare.
2. Understand the design, challenges, and applications of chemical and biochemical wearable sensors.
3. Describe flexible electronics and energy harvesting systems, including low-power circuit design for biopotential sensing and energy harvesting techniques from human body and ambient sources.
4. Apply knowledge of wearable sensors to monitor physical and physiological parameters related to cardiovascular, neurological, and gastrointestinal diseases.
5. Evaluate assistive wearable technologies and devices designed for individuals with severe paralysis, such as tongue drive systems.
6. Understand the concepts and technologies behind remote patient monitoring and telehealth, including practical applications and case studies.

Course Content:

Data Collection and Preprocessing

- Collect data from wearable devices (e.g., smartwatches, fitness trackers)
- Preprocess data by handling missing values, normalization, and feature extraction

Building and Training a Model

- Train a machine learning model to classify physical activities (e.g., walking, running, sleeping) based on wearable data
- Use techniques like time series analysis and sensor fusion to improve model accuracy

Real-time Data Streaming and Analysis

- Set up real-time data streaming from wearable devices to a cloud platform (e.g., AWS IoT, Google Cloud IoT Core)
- Analyze streaming data using AI algorithms (e.g., anomaly detection, pattern recognition)

Remote Health Monitoring

- Develop a remote health monitoring system using AI-powered chatbots or virtual assistants
- Integrate wearable data with electronic health records (EHRs) for personalized health recommendations

Wearable Device Integration

- Integrate wearable devices with mobile apps or web platforms for data visualization and insights
- Use APIs to connect wearable devices to AI-powered analytics platforms

AI-powered Insights and Recommendations

- Develop AI-powered insights and recommendations for users based on wearable data (e.g., stress levels, sleep quality)
- Use natural language processing (NLP) to generate personalized health advice

Security and Privacy

- Implement data encryption and secure data storage for wearable data
- Ensure compliance with regulatory requirements (e.g., HIPAA, GDPR)

Introduction to Remote patient monitoring system, Concept of telehealth, Remote patient monitoring devices, Case studies and applications

Reference Books:

[1] Edward Sazonov, Michael R Neuman, Wearable Sensors: Fundamentals, Implementation and Applications, Academic Press, USA, 2014.

[2]	Tom Bruno, Wearable Technology: Smart Watches to Google Glass for Libraries, Rowman & Littlefield Publishers, Lanham, Maryland, 2015.
[3]	Raymond Tong, Wearable Technology in Medicine and Health Care, Academic Press, USA, 2018.
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Healthcare Informatics privacy and security						
Course Code	AIHC-25009		**Examination Scheme**			
Teaching Scheme	3-0-3		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Analyze privacy, security, and ethical considerations in managing healthcare data.
2. Evaluate the role of mobile technologies, telemedicine, and mobile health applications in modern healthcare delivery.
3. Understand the concepts of quality improvement and patient safety in healthcare informatics, including PACS systems.
4. Apply ethical principles and legal frameworks to the use of artificial intelligence in healthcare.

Module 1: Introduction to Health Informatics: Overview of health informatics Stakeholder perspectives

Module 1: Healthcare Data Trends

Electronic health records Architecture of information systems

Module 2: Healthcare Data Trends

Electronic health records Architecture of information systems

Module 3: Privacy and Security

Health information privacy and security Ethics in healthcare data

Module 5: Mobile Technology in Healthcare Quality Improvement and Patient Safety

Module 6: Ethics of using AI in healthcare

Basic ethical principles (beneficence, autonomy, fairness) and frameworks applied in healthcare

- o **Legal/Regulatory Issues**: Understanding healthcare laws (e.g., HIPAA, GDPR) and AI-related legal responsibilities.
- o **Responsible AI Design**: Best practices for ethical, human-centered ML systems in healthcare.
- o **Case Studies**: Real-world examples highlighting successes and ethical failures in healthcare ML.

Future Challenges: Emerging issues in AI, including genomics and personalized medicine.

Reference Books:

[1]	"Healthcare Information Security and Privacy" *By Sean P. Murphy*
[2]	"Security and Privacy in the Health Care Sector" *Edited by K. El Emam & Lucila Ohno-Machado*
[3]	"Biomedical Informatics: Computer Applications in Health Care and Biomedicine" *By Edward H. Shortliffe & James Cimino*
[4]	"Information Security and Privacy in Healthcare: Current State of Research" *Edited by Hamid Jahankhani, Stefan Kendzierskyj, Kevin Lomas*
[5]	"HIPAA Plain and Simple" *By Carolyn P. Hartley & Edward D. Jones*
[6]	"Protecting Patient Information: A Decision-Maker's Guide to Risk, Prevention, and Damage Control" *By Paul Cerrato*

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<table>
<tr><th colspan="8">Natural Language Processing in Healthcare</th></tr>
<tr><td>Course Code</td><td colspan="2">AIHC(PE)-25005</td><td colspan="5">Examination Scheme</td></tr>
<tr><td>Teaching Scheme</td><td>3-0-3</td><td></td><td>Theory</td><td>TA: 20</td><td>MSE: 30</td><td colspan="2">ESE: 50</td></tr>
<tr><td>Credits</td><td>3</td><td></td><td>Laboratory</td><td>CIE: 50</td><td>ESE: 50</td><td colspan="2">--</td></tr>
<tr><td colspan="8">Course Outcomes: Students will be able to:</td></tr>
<tr><td colspan="8">1. Understand and implement fundamental text processing techniques, including spelling correction and language modeling with advanced smoothing methods.
2. Apply Part-of-Speech (POS) tagging and sequential tagging models such as Maximum Entropy (MaxEnt) and Conditional Random Fields (CRF).
3. Implement entity linking and information extraction methods from unstructured text.
4. Develop systems for text summarization, classification, and sentiment analysis, including opinion mining.</td></tr>
<tr><td colspan="8">Course Content:</td></tr>
<tr><td colspan="8">Introduction and Basic Text Processing; Spelling Correction, Language Modeling; Advanced smoothing for language modeling, POS tagging; Models for Sequential tagging – MaxEnt, CRF; Syntax – Constituency Parsing; Dependency Parsing
Distributional Semantics; Lexical Semantics; Topic Models; Entity Linking, Information Extraction; Text Summarization, Text Classification; Sentiment Analysis and Opinion Mining</td></tr>
<tr><td colspan="8">Reference Book</td></tr>
<tr><td>[1]</td><td colspan="7">Dan Jurafsky and James Martin. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition. Prentice Hall, Second Edition, 2009.</td></tr>
<tr><td>[2]</td><td colspan="7">Some draft chapters of the third edition are available online: https://web.stanford.edu/~jurafsky/slp3/</td></tr>
<tr><td>[3]</td><td colspan="7">Chris Manning and Hinrich Schütze. Foundations of Statistical Natural Language Processing. MIT Press, Cambridge, MA: May 1999.</td></tr>
<tr><td colspan="8">Note:</td></tr>
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[2]

[3]
[4]

[5]</td><td colspan="7">To measure CO1, questions may be of the type- define, identify, state, match, list, name etc.
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</table>

Bio-Implants						
Course Code	AIHC(PE)-25006		**Examination Scheme**			
Teaching Scheme	3-0-3		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE:	ESE:	--

Course Outcomes: Students will be able to:

1. Describe different types of bio-implants, their applications, and historical evolution with insights into future trends.
2. Understand the properties of biomaterials, criteria for selection, and concepts of biocompatibility and tissue engineering.
3. Apply AI and machine learning methods for predictive modeling, image analysis, and bio-signal processing related to bio-implants.
   Analyze case studies on AI-powered bio-implants to evaluate real-world applications and challenges.

Course Content:

1. Module 1: Introduction to Bio-implants
   - Types of bio-implants and their applications
   - Historical perspective and future directions
2. Module 2: Biomaterials and Biocompatibility
   - Properties and selection of biomaterials
   - Biocompatibility and tissue engineering
3. Module 3: Bioelectrical Interfaces and Sensors
   - Electrode design and signal processing
   - Implantable sensors and biosensors
4. Module 4: AI and ML in Bio-implants
   - Predictive modeling for personalized medicine
   - Image analysis for implant placement and monitoring
   - ML algorithms for bio-signal processing
5. Module 5: Case study
   - AI powered bio-implant

Reference Books:

[1]	"Biomaterials Science: An Introduction to Materials in Medicine" *By Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons*
[2]	"Fundamentals of Biomaterials" *By Vasif Hasirci & Nesrin Hasirci*
[3]	"Implantable Biomaterials: Science and Applications" *By Kip A. Surface*
[4]	"Biodegradable Systems in Tissue Engineering and Regenerative Medicine" *By Rui L. Reis and Julio San Román*

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<table>
<tr><th colspan="7">Robotics In Surgery</th></tr>
<tr><td>Course Code</td><td colspan="2">AIHC(PE)-25007</td><td colspan="4">Examination Scheme</td></tr>
<tr><td>Teaching Scheme</td><td>3-0-3</td><td></td><td>Theory</td><td>TA: 20</td><td>MSE: 30</td><td>ESE: 50</td></tr>
<tr><td>Credits</td><td>3</td><td></td><td>Laboratory</td><td>CIE:</td><td>ESE:</td><td>--</td></tr>
</table>

Course Outcomes: Students will be able to:

1. Understand the mechanical design, control systems, and principles of human-robot interaction in surgical robotics.
2. Apply AI and machine learning techniques, including computer vision and predictive modeling, to enhance robotic surgery performance.
3. Analyze clinical benefits of robotic-assisted surgery, including minimally invasive techniques, improved precision, and reduced patient recovery time.
4. Evaluate the challenges in robotic surgery such as regulatory, ethical, and training aspects, and discuss emerging innovations and future directions in the field.

Course Content:

1. Module 1: Introduction to Robotics in Surgery
   - Historical perspective and evolution of robotic surgery
   - Types of robotic systems and their applications
2. Module 2: Robotic System Design and Development
   - Mechanical design and engineering principles
   - Control systems and human-robot interaction
3. Module 3: AI and ML in Robotic Surgery
   - Computer vision for image-guided surgery
   - Predictive modeling for surgical outcome prediction
   - ML algorithms for robotic control and navigation
4. Module 4: Clinical Applications and Benefits
   - Minimally invasive surgery and robotic-assisted procedures
   - Enhanced dexterity and precision
   - Reduced complications and recovery time
5. Module 5: Challenges and Future Directions
   - Regulatory frameworks and ethical considerations
   - Training and education for robotic surgeons
   - Emerging trends and innovations (e.g., autonomous surgery, soft tissue robotics)

Reference Books:

[1] "Surgical Robotics: Systems Applications and Visions" edited by Jacob Rosen, lake Hannaford, and Richard M. Satava.

[2] Artificial Intelligence in Surgery: Understanding the Role of AI in Surgical Practice Authored by Daniel A. Hashimoto, Ozanan R. Meireles, and Guy Rosman.

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Computer Vision						
Course Code	AIHC(PE)-25008		**Examination Scheme**			
Teaching Scheme	3-0-3		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE:	ESE:	--

Course Outcomes: Students will be able to:

1. Understand and apply fundamental concepts of image processing and 2-D projective geometry, including homography and its properties.
2. Apply camera and stereo geometry principles and their applications in 3D vision.
3. Implement feature detection, description, and feature matching techniques, along with robust model fitting methods.
4. Apply color image processing and range image processing techniques to real-world problems.
5. Utilize clustering, classification, dimensionality reduction, and sparse representation methods in image analysis.

Course Content:

Fundamentals of Image processing; 2-D Projective Geometry, homography, and Properties of homography; Camera geometry; Stereo geometry; Stereo geometry
Feature detection and description; Feature matching and model fitting; Color processing; Range image processing; Clustering and classification; Dimensionality reduction and sparse representation; Deep neural architecture and applications

Reference Books:

[1]	.Multiple View Geometry in Computer Vision: R. Hartley and A. Zisserman, Cambridge University Press.
[2]	.Computer Vision: Algorithms & Applications, R. Szeleski, Springer.
[3]	Computer vision: A modern approach: Forsyth and Ponce, Pearson.

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Embedded System for Machine Learning and Deep Learning

Course Code	AIHC(PE)-25009		**Examination Scheme**			
Teaching Scheme	3-0-3		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE:	ESE:	--

Course Outcomes: Students will be able to:

1. Utilize programming languages and development frameworks to design embedded systems supporting AI, ML, and DL models.
2. Develop, train, and deploy AI, ML, and DL models on embedded healthcare systems through practical case studies.
3. Apply performance optimization techniques such as power management and memory optimization to embedded AI systems.
4. Evaluate embedded AI models using appropriate metrics and benchmarks for healthcare applications.

Course Content:

1. Module 1: Embedded Systems in Healthcare
   - Overview of embedded systems and their applications in healthcare
   - Microcontrollers, DSPs, and SoCs for healthcare applications
2. Module 2: Embedded System Programming for AI, ML, and DL
   - Programming languages and tools for embedded systems (e.g., C, C++, Python)
   - Development frameworks and libraries (e.g., TensorFlow, PyTorch)
3. Module 3: Implementing AI, ML, and DL Models on Embedded Systems
   - Case studies of AI, ML, and DL applications in healthcare (e.g., patient monitoring, medical imaging)
   - Model development, training, and deployment on embedded systems
4. Module 4: Optimization and Evaluation
   - Performance optimization techniques for embedded systems (e.g., power management, memory optimization)
   - Evaluation metrics and benchmarks for AI, ML, and DL models on embedded systems
5. Module 5: Advanced Topics
   - Edge AI and IoT applications in healthcare
   - Secure and privacy-preserving AI implementations

Reference Books:

[1] "TinyML: Machine Learning with TensorFlow Lite on Arduino and Ultra-Low-Power Microcontrollers" By Pete Warden & Daniel Situnayake (O’Reilly, 2020)

[2] AI and Machine Learning for On-Device Development: Tools and Techniques for Developing Embedded AI Applications" By Laurence Moroney (O'Reilly, 2021)

[3] "Practical Deep Learning for Cloud, Mobile, and Edge" By Anirudh Koul, Siddha Ganju, and Meher Kasam (O’Reilly)

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