**Proposed New Courses as an Elective Courses, UG Biomedical Engineering Program**

**1.Digital Transformation & Industry 4.0/5.0 technologies (6th Semester, 2+1)**

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| **Course Title** | | Digital Transformation & Industry 4.0/5.0 | | |  |
| **Credit Hours** | | 2+1 | | |
| **Level** | | Undergraduate | | |
| **Course Description** | | | | |
| The healthcare industry is leveraging digital technologies industry 4.0/5.0 technologies including Internet of Things, Big Data, Cloud Computing, additive manufacturing, robotics, AI, and Telemedicine to bring about digital transformation in delivery of healthcare services for improved patient outcomes and overall customer experience with reduced costs.  This course introduces these technologies, their applications, and the opportunities and challenges in the way of leveraging these technologies in the developing countries like Pakistan. The course is supposed to generate a classroom discourse on ethical and privacy implications and provide an opportunity to work on projects in laboratory sessions that demonstrate the practical applications of Industry 4.0 and 5.0 technologies in healthcare. | | | | |
| **Course Learning Outcomes** | | | | |
| **Course Learning Outcomes (CLOs)** | | | **Taxonomy Level** | **PLO** |
| 1 | Explain Digital Technologies including IoT, Big Data, Cloud Computing, Block Chain, AI, Additive manufacturing, robotics, and  Genome Engineering. | | C2 | 1 |
| 2 | Discuss the opportunities and socio-economic challenges in harnessing digital technologies for improving healthcare services. | | C2 | 2 |
| 3 | Evaluate the ethical, legal, and societal implications of digital transformation in healthcare. | | C4 | 8 |
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| **Pre-Requisite Course(s)** | | | | |
| Introduction to Biomedical Engineering | | | | |
| **Course Contents & Assessments** | | | | |
| Indicative Contents and Learning Activities | | | | |
| **Course Contents:**  **Module 1: Introduction to Digital Transformation & Industry 4.0/5.0**   * Fundamentals of digital transformation * Evolution from Industry 3.0 to 5.0 * Role of automation, robotics, and smart systems   **Module 2: Internet of Medical Things (IoMT)**   * Wearable health devices and remote monitoring * IoT-based medical imaging and diagnostics * Data security and privacy challenges in IoMT   **Module 3: Artificial Intelligence & Big Data in Healthcare**   * AI applications in diagnostics and personalized medicine * Machine learning techniques for biomedical applications * Big data analytics and decision support systems   **Module 4: Cybersecurity & Ethical Considerations**   * Cyber threats in digital healthcare * Regulatory frameworks and compliance (HIPAA, GDPR) * Ethical implications of AI and automation in medicine   **Module 5: Smart Healthcare Systems & Case Studies**   * Digital twin technology in healthcare * Blockchain for secure medical data management * Case studies on successful implementation of Industry 4.0/5.0 in biomedical engineering. | | | | |

**2. Computer Aided Diagnostics (8th Semester, 2+1)**

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| **Course Title** | | Computer Aided Diagnostics (CAD) | | |
| **Credit Hours** | | 2+1, 8th Semester | | |
| **Level** | | Undergraduate | | |
| **Course Description** | | | | |
| This course will cover technologies used for early disease detection using image processing and analysis. The course would explain the extraction of regions of interest in the images acquired using various diagnostic modalities (CT, MRI, PET, etc.). The students will gain knowledge and understanding of image enhancement, analysis, and classification using artificial intelligence and deep learning techniques. The module will also briefly introduce computer-assisted systems for diagnosis, decision-making, and decision support in various medical applications. | | | | |
| **Course Learning Outcomes** | | | | |
| **Course Learning Outcomes (CLOs)** | | | **Taxonomy Level** | **PLO** |
| 1 | **Explain** image analysis, classification, and segmentation techniques useful in CAD environment. | | C2 | 1 |
| 2 | **Apply** the knowledge of CAD system principles and medical image processing techniques for improved diagnostic accuracy. | | C3 | 3 |
| 3 | **Design** a CAD system for medical diagnosis to make informed decisions based on systems findings. | | C6 | 4 |
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| **Prerequisite learning** | | | | |
| Digital Signal Processing and Medical Imaging | | | | |
| **Course Contents** | | | | |
| **Module 1: Introduction to Computer-Aided Diagnostics**   * Overview of CAD systems in healthcare * Role of AI and machine learning in CAD * Historical development and future trends   **Module 2: Medical Imaging in CAD**   * Common imaging modalities (X-ray, MRI, CT, Ultrasound) * Preprocessing techniques for medical images * Image segmentation and feature extraction   **Module 3: Machine Learning & AI in CAD**   * Supervised vs. unsupervised learning * Deep learning models for medical diagnosis * AI-based image classification and pattern recognition   **Module 4: Performance Evaluation & Validation**   * Sensitivity, specificity, and accuracy metrics * ROC curves and AUC analysis * Cross-validation techniques in CAD systems   **Module 5: CAD Applications & Case Studies**   * CAD in radiology, oncology, cardiology, and pathology * CAD-assisted decision-making in clinical practice * Case studies of successful CAD implementations   **Module 6: Ethical & Regulatory Considerations**   * Challenges in AI-based diagnostics * Regulatory frameworks and FDA approvals * Ethical concerns in automated diagnosis | | | | |