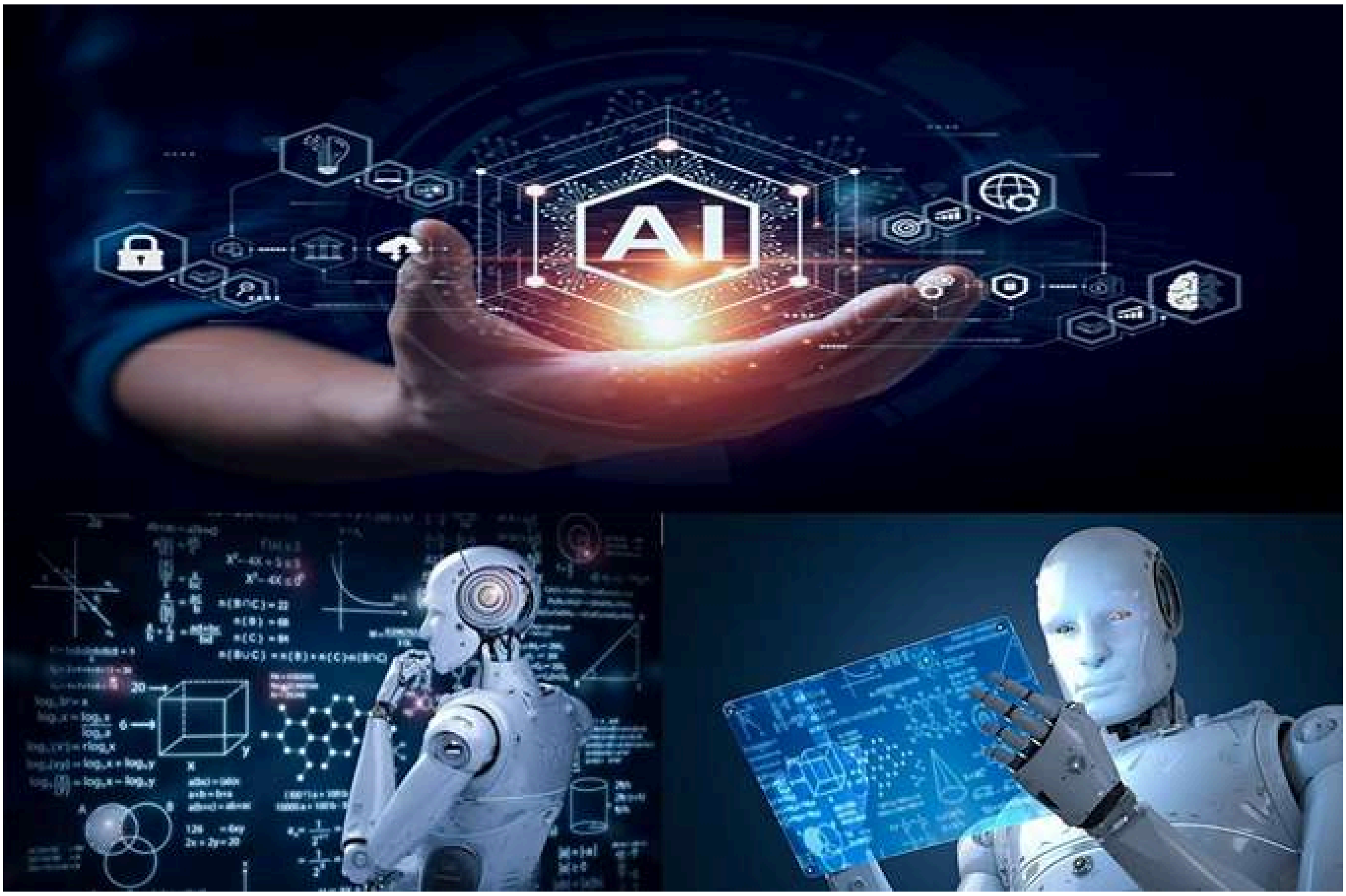
Logo
Not
Available

**Qualification Pack**



# A.I (Artificial Intelligence) - Technocrat

Electives: Application in CS & IT Domain/ Applications of AI in ECE Domain/ Applications of AI in Electrical Domain/ Applications of AI in Mechanical Domain/ Applications of AI in Civil Domain/ Applications of AI in Metallurgy Domain

QP Code: ICE/ITS/Q0201

Version: 1.0

NSQF Level: 5

THE INSTITUTION OF CIVIL ENGINEERS SOCIETY || 533-R

# Contents

ICE/ITS/Q0201: A.I (Artificial Intelligence) - Technocrat ........ 4
*Brief Job Description* ........ 4
Applicable National Occupational Standards (NOS) ........ 4
*Compulsory NOS* ........ 4
*Elective 1: Application in CS & IT Domain* ........ 4
*Elective 2: Applications of AI in ECE Domain* ........ 4
*Elective 3: Applications of AI in Electrical Domain* ........ 5
*Elective 4: Applications of AI in Mechanical Domain* ........ 5
*Elective 5: Applications of AI in Civil Domain* ........ 5
*Elective 6: Applications of AI in Metallurgy Domain* ........ 5
*Qualification Pack (QP) Parameters* ........ 5
ICE/ITS/N0201: Fundamentals of Artificial Intelligence (AI) ........ 7
ICE/ITS/N0202: Python Programming and data science for AI ........ 14
ICE/ITS/N0203: Building Blocks of Artificial Intelligence (A.I) ........ 21
DGT/VSQ/N0102: Employability Skills (60 Hours) ........ 29
ICE/ITS/N0204: Applications of AI tools/algorithms in Computer Science and Information Technology Engineering ........ 37
ICE/ITS/N0205: Applications of AI tools/algorithms in Electronics & Communication Engineering ..... 46
ICE/ITS/N0206: Applications of AI tools/algorithms in Electrical Engineering ........ 58
ICE/ITS/N0207: Applications of AI tools/algorithms in Mechanical Engineering ........ 70
ICE/ITS/N0208: Applications of AI tools/algorithms in Civil Engineering ........ 82
ICE/ITS/N0209: Applications of AI tools/algorithms in Metallurgical and Materials Engineering ........ 95
Assessment Guidelines and Weightage ........ 104
*Assessment Guidelines* ........ 104
*Assessment Weightage* ........ 105
Acronyms ........ 108
Glossary ........ 109

# ICE/ITS/Q0201: A.I (Artificial Intelligence) - Technocrat

## Brief Job Description

AI Technocrats design and implement artificial intelligence solutions across diverse engineering disciplines. They optimize systems and processes using intelligent algorithms and automation, enhancing efficiency and innovation. Their work focuses on developing AI-driven tools that address industry challenges while promoting sustainability by reducing waste and energy consumption, ultimately fostering ecological balance and improving operational performance across various Engineering sectors.

## Personal Attributes

They are analytical, adaptive collaborative with strong problem-solving skills and a commitment to continuous learning in AI technologies.

## Applicable National Occupational Standards (NOS)

### Compulsory NOS:

1. ICE/ITS/N0201: Fundamentals of Artificial Intelligence (AI)
2. ICE/ITS/N0202: Python Programming and data science for AI
3. ICE/ITS/N0203: Building Blocks of Artificial Intelligence (A.I)
4. DGT/VSQ/N0102: Employability Skills (60 Hours)

### Electives*(mandatory to select at least one)*:

### Elective 1: Application in CS & IT Domain

The application of AI tools and algorithms in the fields of Computer Science (CS) and Information Technology (IT) engineering encompasses a wide range of innovative solutions and methodologies. These applications enhance system efficiency, automate processes, and improve data analysis by leveraging machine learning, natural language processing, and computer vision technologies. AI-driven techniques are utilized for software development, network security, data management, and user experience optimization, enabling professionals to address complex challenges and drive technological advancements in the industry. As AI continues to evolve, its integration into CS and IT will play a crucial role in shaping future innovations and operational strategies.

1. ICE/ITS/N0204: Applications of AI tools/algorithms in Computer Science and Information Technology Engineering

### Elective 2: Applications of AI in ECE Domain

This focuses on the applications of artificial intelligence (AI) tools and algorithms within the field of Electronics and Communication Engineering (ECE). It explores various ways AI can enhance and innovate the design, analysis, and optimization of electronic systems and communication networks. Topics may include machine learning, data processing, signal analysis, and smart communication techniques, highlighting real-world applications and emerging trends in the ECE domain. This course aims to equip students with the knowledge and skills to effectively integrate AI technologies into ECE practices.

1. ICE/ITS/N0205: Applications of AI tools/algorithms in Electronics & Communication Engineering

### Elective 3: Applications of AI in Electrical Domain

This explores the various applications of artificial intelligence (AI) tools and algorithms within the field of electrical engineering. It covers how AI technologies can enhance electrical systems, improve efficiency, and enable advanced problem-solving techniques in design, analysis, and operation. Through a combination of theoretical concepts and practical examples, participants will gain insights into integrating AI methodologies into electrical engineering practices.

1. ICE/ITS/N0206: Applications of AI tools/algorithms in Electrical Engineering

### Elective 4: Applications of AI in Mechanical Domain

This course examines the applications of artificial intelligence (AI) tools and algorithms within the field of Mechanical Engineering. It explores how AI can enhance design processes, optimize performance, and improve predictive maintenance, ultimately leading to increased efficiency and innovation in mechanical systems and technologies.

1. ICE/ITS/N0207: Applications of AI tools/algorithms in Mechanical Engineering

### Elective 5: Applications of AI in Civil Domain

This document, identifies and explores the various applications of artificial intelligence (AI) tools and algorithms within the field of civil engineering. It outlines how AI can enhance processes such as design, construction, project management, and maintenance, ultimately leading to increased efficiency, improved safety, and more sustainable practices in civil engineering projects.

1. ICE/ITS/N0208: Applications of AI tools/algorithms in Civil Engineering

### Elective 6: Applications of AI in Metallurgy Domain

This document explores the applications of artificial intelligence (AI) tools and algorithms in the field of Metallurgical and Materials Engineering. It highlights how AI can enhance processes such as material design, quality control, and predictive maintenance, ultimately improving efficiency and innovation in metallurgy. By integrating advanced AI techniques, professionals in the metallurgy domain can unlock new opportunities for research and development, leading to better performance and sustainability of materials.

1. ICE/ITS/N0209: Applications of AI tools/algorithms in Metallurgical and Materials Engineering

## Qualification Pack (QP) Parameters

| | |
|---|---|
| **Sector** | Information Technology Sector |
| **Sub-Sector** | Future skills |
| **Occupation** | Artificial Intelligence |
| **Country** | India |
| **NSQF Level** | 5 |
| **Credits** | NaN |
| **Aligned to NCO/ISCO/ISIC Code** | NCO-2015/3123.0302 & 3123.0400 & 3122.5600 |
| **Minimum Educational Qualification & Experience** | Completed 2nd year of UG (UG Diploma)<br>OR<br>Pursuing 2nd year of UG (3 years / 4 years)<br>OR<br>Completed 2nd year diploma after 12th<br>OR<br>Completed 3 year diploma after 10th with 1.5 years of experience relevant stream experience<br>OR<br>Previous relevant Qualification of NSQF Level (4.5) with 1.5 years of experience relevant stream experience |
| **Minimum Level of Education for Training in School** | Not Applicable |
| **Pre-Requisite License or Training** | NA |
| **Minimum Job Entry Age** | 18 Years |
| **Last Reviewed On** | NA |
| **Next Review Date** | 17/12/2027 |
| **NSQC Approval Date** | 17/12/2024 |
| **Version** | 1.0 |
| **Reference code on NQR** | QG-05-IT-03423-2024-V1-TICE |
| **NQR Version** | 1 |

# ICE/ITS/N0201: Fundamentals of Artificial Intelligence (AI)

## Description

This unit covers the Fundamental of Artificial Intelligence (AI) exploring the foundational ideas, key techniques and widespread use of A.I across various fields.

## Scope

The scope covers the following :

- This introductory unit explores core concepts like machine learning, neural networks, and natural language processing. And on how AI is applied in automation, decision-making, and problem-solving. Furthermore, this also addresses the ethical implications, current limitations, and the exciting future prospects of AI technology.

## Elements and Performance Criteria

### *Introduction to AI*

To be competent, the user/individual on the job must be able to:

**PC1.** Understand the basic concepts and definitions of Artificial Intelligence and its significance in various technical trades.

**PC2.** Demonstrate knowledge of AI applications in technical fields, such as predictive maintenance, automation, quality control, and resource optimization.

**PC3.** Explain the role of machine learning and data analytics in enhancing decision-making processes within technical trades.

**PC4.** Understand the importance of data collection and management for effective AI implementation including the use of IoT devices and sensors.

**PC5.** Evaluate the impact of AI on workflow efficiency, cost reduction, and productivity improvement in various technical trades.

### *The Ethical Landscape of AI and its Societal Impact*

To be competent, the user/individual on the job must be able to:

**PC6.** Understand the core principles of AI ethics, including fairness, accountability, transparency, and the responsible use of AI technologies.

**PC7.** Describe the impact of AI on privacy and surveillance, discussing the ethical considerations surrounding data collection and user consent.

**PC8.** Explore the implications of AI on employment and workforce dynamics including the potential for job displacement and the need for workforce reskilling.

**PC9.** Understand the importance of regulatory frameworks and policies in governing AI technologies to ensure ethical practices and protect societal interests.

**PC10.** Analyze ethical considerations and challenges associated with the adoption of AI technologies, such as data privacy concerns, potential job displacement, and algorithmic bias

**PC11.** Discuss the potential societal benefits of AI, such as improved healthcare, enhanced public safety, and advancements in education while recognising the associated ethical challenges.

### *Aptitude & Mathematics Fundamentals*

To be competent, the user/individual on the job must be able to:

**PC12.** Describe basic mathematical concepts, including algebra, calculus, and statistics, essential for understanding AI algorithms and models.

**PC13.** Understand the principles of linear algebra, including vectors, matrices, and operations, and their applications in machine learning and data manipulation.

**PC14.** Discuss probability theory to analyse uncertainty in AI models, including concepts such as conditional probability, Bayes' theorem, and distributions

**PC15.** Explain statistical methods for data analysis, including hypothesis testing, regression analysis and descriptive statistics.

**PC16.** Understand the significance of optimization techniques, including gradient descent and convex optimization in training machine learning models.

*Data Handling*

To be competent, the user/individual on the job must be able to:

**PC17.** Understand the importance of data quality and data cleaning processes including handling missing values, outliers and duplicates to ensure reliable AI model performance.

**PC18.** Explain data pre-processing techniques, such as normalization, standardization, and encoding categorical variables, to prepare data for analysis

**PC19.** Describe data exploration and visualization techniques using tools like Matplotlib and Seaborn to understand data distributions, correlations, and trends.

**PC20.** Understand the significance of data splitting methods (e.g., training, validation, and test sets) in building robust AI models and preventing overfitting.

**PC21.** Examine techniques for storing and retrieving data, including databases, data lakes, and data warehouses, for effective data management.

## Knowledge and Understanding (KU)

The individual on the job needs to know and understand:

**KU1.** Core definition of Artificial Intelligence and its distinction from traditional computing, including concepts like machine learning, deep learning, and neural networks.

**KU2.** Historical development of AI, key milestones, and influential figures in the field.

**KU3.** Different types of AI, including narrow AI (specific tasks) and general AI (human-like capabilities), along with their implications.

**KU4.** Fundamental concepts of machine learning, including supervised, unsupervised, and reinforcement learning paradigms

**KU5.** Critical role of data in AI, including data collection, pre-processing, and the significance of high- quality datasets for model training.

**KU6.** Key algorithms used in AI and machine learning, such as decision trees, support vector machines, and neural networks

**KU7.** Various applications of AI across industries, including healthcare, finance, transportation, and entertainment, and their societal impact.

**KU8.** Awareness of emerging trends in AI, such as advancements in natural language processing, computer vision.

## Generic Skills (GS)

User/individual on the job needs to know how to:

- **GS1.** Listen and communicate effectively and accurately.
- **GS2.** Apply problem-solving approaches for different situations.
- **GS3.** Work effectively in a team.
- **GS4.** Employ proper time management.
- **GS5.** Plan and organize work.
- **GS6.** Maintain hygiene and sanitation.
- **GS7.** Apply analytical skills for solving problems.

## Assessment Criteria

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| *Introduction to AI* | **10** | **10** | **-** | **2** |
| **PC1.** Understand the basic concepts and definitions of Artificial Intelligence and its significance in various technical trades. | - | - | - | - |
| **PC2.** Demonstrate knowledge of AI applications in technical fields, such as predictive maintenance, automation, quality control, and resource optimization. | - | - | - | - |
| **PC3.** Explain the role of machine learning and data analytics in enhancing decision-making processes within technical trades. | - | - | - | - |
| **PC4.** Understand the importance of data collection and management for effective AI implementation including the use of IoT devices and sensors. | - | - | - | - |
| **PC5.** Evaluate the impact of AI on workflow efficiency, cost reduction, and productivity improvement in various technical trades. | - | - | - | - |
| *The Ethical Landscape of AI and its Societal Impact* | **10** | **10** | **-** | **2** |
| **PC6.** Understand the core principles of AI ethics, including fairness, accountability, transparency, and the responsible use of AI technologies. | - | - | - | - |
| **PC7.** Describe the impact of AI on privacy and surveillance, discussing the ethical considerations surrounding data collection and user consent. | - | - | - | - |
| **PC8.** Explore the implications of AI on employment and workforce dynamics including the potential for job displacement and the need for workforce reskilling. | - | - | - | - |
| **PC9.** Understand the importance of regulatory frameworks and policies in governing AI technologies to ensure ethical practices and protect societal interests. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC10.** Analyze ethical considerations and challenges associated with the adoption of AI technologies, such as data privacy concerns, potential job displacement, and algorithmic bias | - | - | - | - |
| **PC11.** Discuss the potential societal benefits of AI, such as improved healthcare, enhanced public safety, and advancements in education while recognising the associated ethical challenges. | - | - | - | - |
| *Aptitude & Mathematics Fundamentals* | **10** | **15** | **-** | **3** |
| **PC12.** Describe basic mathematical concepts, including algebra, calculus, and statistics, essential for understanding AI algorithms and models. | - | - | - | - |
| **PC13.** Understand the principles of linear algebra, including vectors, matrices, and operations, and their applications in machine learning and data manipulation. | - | - | - | - |
| **PC14.** Discuss probability theory to analyse uncertainty in AI models, including concepts such as conditional probability, Bayes' theorem, and distributions | - | - | - | - |
| **PC15.** Explain statistical methods for data analysis, including hypothesis testing, regression analysis and descriptive statistics. | - | - | - | - |
| **PC16.** Understand the significance of optimization techniques, including gradient descent and convex optimization in training machine learning models. | - | - | - | - |
| *Data Handling* | **10** | **15** | **-** | **3** |
| **PC17.** Understand the importance of data quality and data cleaning processes including handling missing values, outliers and duplicates to ensure reliable AI model performance. | - | - | - | - |
| **PC18.** Explain data pre-processing techniques, such as normalization, standardization, and encoding categorical variables, to prepare data for analysis | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC19.** Describe data exploration and visualization techniques using tools like Matplotlib and Seaborn to understand data distributions, correlations, and trends. | - | - | - | - |
| **PC20.** Understand the significance of data splitting methods (e.g., training, validation, and test sets) in building robust AI models and preventing overfitting. | - | - | - | - |
| **PC21.** Examine techniques for storing and retrieving data, including databases, data lakes, and data warehouses, for effective data management. | - | - | - | - |
| **NOS Total** | **40** | **50** | **-** | **10** |

## National Occupational Standards (NOS) Parameters

| | |
|---|---|
| **NOS Code** | ICE/ITS/N0201 |
| **NOS Name** | Fundamentals of Artificial Intelligence (AI) |
| **Sector** | Information Technology Sector |
| **Sub-Sector** | |
| **Occupation** | Artificial Intelligence |
| **NSQF Level** | 5 |
| **Credits** | 1.5 |
| **Version** | 1.0 |
| **Last Reviewed Date** | 17/12/2024 |
| **Next Review Date** | 17/12/2027 |
| **NSQC Clearance Date** | 17/12/2024 |

# ICE/ITS/N0202: Python Programming and data science for AI

## Description

This module emphasizes the use of Python for developing and applying AI algorithms. It provides a comprehensive overview of how to implement these technologies effectively. Participants will learn to harness Python's capabilities in the field of artificial intelligence.

## Scope

The scope covers the following :

- It covers Python libraries such as NumPy, Pandas, TensorFlow, and PyTorch, which are essential for machine learning and deep learning data processing. This also includes practical programming techniques for building AI models, handling datasets, and creating AI-powered solutions.

## Elements and Performance Criteria

### *Introduction to Python Programming*

To be competent, the user/individual on the job must be able to:

**PC1.** Understand Python syntax, including variables, data types, loops, and conditionals for basic programming tasks.

**PC2.** Discuss fundamental Python data structures such as lists, dictionaries, tuples, and sets in data manipulation.

**PC3.** Discuss to utilize Python functions and modules to write reusable and efficient code.

**PC4.** Understand to use Python for file handling operations such as reading from and writing to files.

**PC5.** Describe to use of Python libraries like NumPy and Pandas for basic data manipulation and analysis tasks.

**PC6.** Discuss basic debugging and error-handling techniques to identify and resolve issues in Python programs

### *Data Structures and Algorithms in Python*

To be competent, the user/individual on the job must be able to:

**PC7.** Understand the fundamentals data structures such as arrays, linked lists, stacks, queues, trees, and graphs in Python.

**PC8.** Describe to utilize Python's built-in data structures, such as lists, dictionaries, sets, and tuples, to solve problems effectively.

**PC9.** Discuss common algorithms for sorting (e.g., bubble sort, quicksort, mergesort) and searching (e.g., linear search, binary search) on various data structures.

**PC10.** Understand the concepts of complexity analysis, including time and space complexity, to evaluate the efficiency of algorithms.

**PC11.** Describe recursion and its applications in solving problems, including tree traversal and backtracking algorithms.

**PC12.** Understand to solve practical problems and to utilize data structures to optimize performance in Python applications.

*Object-Oriented Programming (OOP) in Python*

To be competent, the user/individual on the job must be able to:

**PC13.** Understand the core principles of Object-Oriented Programming (OOP), including encapsulation, inheritance, and polymorphism.

**PC14.** Define to use classes and objects in Python to model real-world entities and behaviors.

**PC15.** Discuss constructor and destructor methods to initialize and clean up object attributes in Python classes.

**PC16.** Understand to utilize class inheritance to create subclasses to extend or modify the functionality of parent classes.

**PC17.** Describe method overriding to customize the behavior of inherited methods in derived classes.

**PC18.** Discuss the concept of abstraction through abstract classes and interfaces to understand the design concept of flexible and modular code.

*Libraries for AI and Data Science*

To be competent, the user/individual on the job must be able to:

**PC19.** Understand to use NumPy for numerical computations including array manipulation, mathematical operations and linear algebra.

**PC20.** Describe Pandas for data manipulation and analysis to utilize dataFrames for data cleaning, transformation and aggregation tasks.

**PC21.** Understand data visualization techniques using Matplotlib and Seaborn to create informative plots and graphs Seaborn.

**PC22.** Discuss to utilize Scikit-learn for building and evaluating machine learning models, including data preprocessing, feature selection and model selection techniques.

**PC23.** Understand to use TensorFlow or PyTorch for developing and training deep learning models, including defining architectures and optimizing performance.

**PC24.** Discuss Natural Language Toolkit (NLTK) or spaCy for text processing tasks in Natural Language Processing (NLP), including tokenization, stemming and recognition.

## Knowledge and Understanding (KU)

The individual on the job needs to know and understand:

**KU1.** Core syntax and fundamental concepts of Python, including variables, data types, control structures, functions, and error handling.

**KU2.** Python data structures such as lists, tuples, dictionaries, and sets, and their appropriate use cases in programming.

**KU3.** Key Python libraries used in data science and AI, including NumPy for numerical operations, Pandas for data manipulation, and Matplotlib/Seaborn for data visualization

**KU4.** Methods for cleaning and preprocessing data, including handling missing values, normalization, standardization, and encoding categorical variables.

**KU5.** Principles of object-oriented programming (OOP) in Python, including classes, objects, inheritance, encapsulation, and polymorphism.

**KU6.** Ability to create visualizations to interpret data and communicate findings effectively using libraries like Matplotlib and Seaborn.

## Generic Skills (GS)

User/individual on the job needs to know how to:

**GS1.** Listen and communicate effectively and accurately.
**GS2.** Apply problem-solving approaches for different situations
**GS3.** Work effectively in a team.
**GS4.** Employ proper time management.
**GS5.** Plan and organize work.
**GS6.** Maintain hygiene and sanitation.
**GS7.** Analytical skills.

## Assessment Criteria

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| *Introduction to Python Programming* | **10** | **10** | **-** | **2** |
| **PC1.** Understand Python syntax, including variables, data types, loops, and conditionals for basic programming tasks. | - | - | - | - |
| **PC2.** Discuss fundamental Python data structures such as lists, dictionaries, tuples, and sets in data manipulation. | - | - | - | - |
| **PC3.** Discuss to utilize Python functions and modules to write reusable and efficient code. | - | - | - | - |
| **PC4.** Understand to use Python for file handling operations such as reading from and writing to files. | - | - | - | - |
| **PC5.** Describe to use of Python libraries like NumPy and Pandas for basic data manipulation and analysis tasks. | - | - | - | - |
| **PC6.** Discuss basic debugging and error-handling techniques to identify and resolve issues in Python programs | - | - | - | - |
| *Data Structures and Algorithms in Python* | **10** | **15** | **-** | **3** |
| **PC7.** Understand the fundamentals data structures such as arrays, linked lists, stacks, queues, trees, and graphs in Python. | - | - | - | - |
| **PC8.** Describe to utilize Python's built-in data structures, such as lists, dictionaries, sets, and tuples, to solve problems effectively. | - | - | - | - |
| **PC9.** Discuss common algorithms for sorting (e.g., bubble sort, quicksort, mergesort) and searching (e.g., linear search, binary search) on various data structures. | - | - | - | - |
| **PC10.** Understand the concepts of complexity analysis, including time and space complexity, to evaluate the efficiency of algorithms. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC11.** Describe recursion and its applications in solving problems, including tree traversal and backtracking algorithms. | - | - | - | - |
| **PC12.** Understand to solve practical problems and to utilize data structures to optimize performance in Python applications. | - | - | - | - |
| *Object-Oriented Programming (OOP) in Python* | **10** | **15** | **-** | **3** |
| **PC13.** Understand the core principles of Object-Oriented Programming (OOP), including encapsulation, inheritance, and polymorphism. | - | - | - | - |
| **PC14.** Define to use classes and objects in Python to model real-world entities and behaviors. | - | - | - | - |
| **PC15.** Discuss constructor and destructor methods to initialize and clean up object attributes in Python classes. | - | - | - | - |
| **PC16.** Understand to utilize class inheritance to create subclasses to extend or modify the functionality of parent classes. | - | - | - | - |
| **PC17.** Describe method overriding to customize the behavior of inherited methods in derived classes. | - | - | - | - |
| **PC18.** Discuss the concept of abstraction through abstract classes and interfaces to understand the design concept of flexible and modular code. | - | - | - | - |
| *Libraries for AI and Data Science* | **10** | **10** | **-** | **2** |
| **PC19.** Understand to use NumPy for numerical computations including array manipulation, mathematical operations and linear algebra. | - | - | - | - |
| **PC20.** Describe Pandas for data manipulation and analysis to utilize dataFrames for data cleaning, transformation and aggregation tasks. | - | - | - | - |
| **PC21.** Understand data visualization techniques using Matplotlib and Seaborn to create informative plots and graphs Seaborn. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC22.** Discuss to utilize Scikit-learn for building and evaluating machine learning models, including data preprocessing, feature selection and model selection techniques. | - | - | - | - |
| **PC23.** Understand to use TensorFlow or PyTorch for developing and training deep learning models, including defining architectures and optimizing performance. | - | - | - | - |
| **PC24.** Discuss Natural Language Toolkit (NLTK) or spaCy for text processing tasks in Natural Language Processing (NLP), including tokenization, stemming and recognition. | - | - | - | - |
| **NOS Total** | **40** | **50** | **-** | **10** |

## National Occupational Standards (NOS) Parameters

| | |
|---|---|
| **NOS Code** | ICE/ITS/N0202 |
| **NOS Name** | Python Programming and data science for AI |
| **Sector** | Information Technology Sector |
| **Sub-Sector** | |
| **Occupation** | Artificial Intelligence |
| **NSQF Level** | 5 |
| **Credits** | 3.5 |
| **Version** | 1.0 |
| **Last Reviewed Date** | 17/12/2024 |
| **Next Review Date** | 17/12/2027 |
| **NSQC Clearance Date** | 17/12/2024 |

# ICE/ITS/N0203: Building Blocks of Artificial Intelligence (A.I)

## Description

The Build Blocks of A.I. Specializations provide essential knowledge in AI concepts, algorithms, and methodologies across various domains, including machine learning and natural language processing, computer vision, Internet of things and Robotics.

## Scope

The scope covers the following :

- Practical applications in diverse industries.
- Addresses ethical implications and responsible AI use.
- Fosters innovation to solve real-world problems with AI technologies.

## Elements and Performance Criteria

*Fundamentals of Machine Learning (ML)*

To be competent, the user/individual on the job must be able to:

**PC1.** Explain the core concepts of supervised, unsupervised, and reinforcement learning.

**PC2.** Understand regression and classification models.

**PC3.** Discuss data preprocessing techniques, such as normalization and feature extraction to prepare data for ML models.

**PC4.** Explain key ML algorithms, such as decision trees, support vector machines, and k-means clustering.

**PC5.** Describe model performance using metrics like accuracy, precision, recall, F1-score, and ROC curves.

**PC6.** Understand model optimization techniques, including hyperparameter tuning and cross-validation.

*Basics of Deep Learning*

To be competent, the user/individual on the job must be able to:

**PC7.** Understand the core architecture of artificial neural networks (ANNs), including layers, nodes, and activation functions.

**PC8.** Discuss building and training feedforward neural networks using deep learning frameworks (e.g., TensorFlow, PyTorch).

**PC9.** Explain the concept of backpropagation and its role in optimizing neural networks.

**PC10.** Describe convolutional neural networks (CNNs) for image-related tasks such as classification and object detection.

**PC11.** Understand the basics of recurrent neural networks (RNNs) and their applications in sequence data like time series and natural language.

**PC12.** Understand to utilize regularization techniques to prevent overfitting in deep learning models.

*Fundamentals of Natural Language Processing (NLP)*

To be competent, the user/individual on the job must be able to:

**PC13.** Understand the basic concepts of tokenization, stemming, and lemmatization for text preprocessing.

**PC14.** Explain building and applying language models for text prediction and generation.

**PC15.** Explain the use of word embeddings (e.g., Word2Vec, GloVe) to represent text data as vectors in NLP tasks.

**PC16.** Describe NLP techniques for tasks such as sentiment analysis, text classification and named entity recognition (NER).

**PC17.** Understand sequence-to-sequence models for machine translation, summarization and other text-based tasks.

**PC18.** Understand to evaluate metrics like BLEU, ROUGE to assess the performance of NLP models.

*Basics of Computer Vision*

To be competent, the user/individual on the job must be able to:

**PC19.** Understand the key concepts of image processing such as filtering, edge detection and image enhancement.

**PC20.** Discuss building and applying Convolutional Neural Networks (CNNs) for tasks like image classification and object detection.

**PC21.** Describe techniques for image segmentation to separate objects or regions within an image.

**PC22.** Discuss image augmentation techniques to improve model generalization and performance on visual tasks.

**PC23.** Explain the principles of object tracking and motion detection in video processing.

**PC24.** Understand feature extraction methods like SIFT, SURF, and ORB for object recognition and computer vision applications.

*Fundamentals of Internet of Things (IoT)*

To be competent, the user/individual on the job must be able to:

**PC25.** Understand the basic architecture of IoT systems, including sensors, actuators, and communication protocols.

**PC26.** Explain to connect and configure IoT devices for data collection and monitoring.

**PC27.** Explain the role of edge computing and its integration with IoT to process data locally for faster responses.

**PC28.** Understand the principles of IoT communication protocols such as MQTT, CoAP, and HTTP, and their applications.

**PC29.** Describe data security and privacy concerns in IoT systems, including encryption and authentication techniques.

**PC30.** Describe IoT for smart systems design, such as smart homes, industrial automation, or environmental monitoring.

*Basics of Robotics*

To be competent, the user/individual on the job must be able to:

**PC31.** Explain the fundamental concepts of robot kinematics, including forward and inverse kinematics for robot movement and positioning.

**PC32.** Understand the programming robot control systems for tasks such as navigation, manipulation, and automation.

**PC33.** Discuss sensor integration (e.g., cameras, LIDAR, ultrasonic sensors) for robot perception and environment interaction.

**PC34.** Understand the basics of robot dynamics and forces and torques affect robot motion and stability.

**PC35.** Understand ability to implement robot path planning algorithms to enable autonomous navigation in dynamic environments.

**PC36.** Discuss robotic learning techniques, such as reinforcement learning, to improve robot decision-making and task execution.

## Knowledge and Understanding (KU)

The individual on the job needs to know and understand:

**KU1.** Basic concepts of machine learning, including different types of learning (supervised, unsupervised, and reinforcement) and their applications in various domains.

**KU2.** Deep learning architectures, including neural networks, convolutional neural networks (CNNs), and recurrent neural networks (RNNs), and their role in AI advancements.

**KU3.** Fundamental techniques and tools used in NLP, such as tokenization, stemming, and sentiment analysis, and their applications in text and speech processing.

**KU4.** Principles of computer vision, including image processing techniques, feature extraction, and object detection, along with their applications in industries like healthcare and automotive.

**KU5.** IoT concepts, including sensor integration, data collection, and the use of AI in smart devices for automation and enhanced decision-making.

**KU6.** Principles of robotics, including perception, decision-making, and control systems, and AI technologies are integrated to improve robot functionalities.

## Generic Skills (GS)

User/individual on the job needs to know how to:

**GS1.** Listen and communicate effectively and accurately.

**GS2.** Apply problem-solving approaches for different situations.

**GS3.** Work effectively in a team.

**GS4.** Employ proper time management.

**GS5.** Plan and organize work.

**GS6.** Maintain hygiene and sanitation.

**GS7.** Analytical Skills.

## Assessment Criteria

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| *Fundamentals of Machine Learning (ML)* | **7** | **9** | **-** | **2** |
| **PC1.** Explain the core concepts of supervised, unsupervised, and reinforcement learning. | - | - | - | - |
| **PC2.** Understand regression and classification models. | - | - | - | - |
| **PC3.** Discuss data preprocessing techniques, such as normalization and feature extraction to prepare data for ML models. | - | - | - | - |
| **PC4.** Explain key ML algorithms, such as decision trees, support vector machines, and k-means clustering. | - | - | - | - |
| **PC5.** Describe model performance using metrics like accuracy, precision, recall, F1-score, and ROC curves. | - | - | - | - |
| **PC6.** Understand model optimization techniques, including hyperparameter tuning and cross-validation. | - | - | - | - |
| *Basics of Deep Learning* | **7** | **9** | **-** | **2** |
| **PC7.** Understand the core architecture of artificial neural networks (ANNs), including layers, nodes, and activation functions. | - | - | - | - |
| **PC8.** Discuss building and training feedforward neural networks using deep learning frameworks (e.g., TensorFlow, PyTorch). | - | - | - | - |
| **PC9.** Explain the concept of backpropagation and its role in optimizing neural networks. | - | - | - | - |
| **PC10.** Describe convolutional neural networks (CNNs) for image-related tasks such as classification and object detection. | - | - | - | - |
| **PC11.** Understand the basics of recurrent neural networks (RNNs) and their applications in sequence data like time series and natural language. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC12.** Understand to utilize regularization techniques to prevent overfitting in deep learning models. | - | - | - | - |
| *Fundamentals of Natural Language Processing (NLP)* | **7** | **8** | **-** | **2** |
| **PC13.** Understand the basic concepts of tokenization, stemming, and lemmatization for text preprocessing. | - | - | - | - |
| **PC14.** Explain building and applying language models for text prediction and generation. | - | - | - | - |
| **PC15.** Explain the use of word embeddings (e.g., Word2Vec, GloVe) to represent text data as vectors in NLP tasks. | - | - | - | - |
| **PC16.** Describe NLP techniques for tasks such as sentiment analysis, text classification and named entity recognition (NER). | - | - | - | - |
| **PC17.** Understand sequence-to-sequence models for machine translation, summarization and other text-based tasks. | - | - | - | - |
| **PC18.** Understand to evaluate metrics like BLEU, ROUGE to assess the performance of NLP models. | - | - | - | - |
| *Basics of Computer Vision* | **6** | **8** | **-** | **1** |
| **PC19.** Understand the key concepts of image processing such as filtering, edge detection and image enhancement. | - | - | - | - |
| **PC20.** Discuss building and applying Convolutional Neural Networks (CNNs) for tasks like image classification and object detection. | - | - | - | - |
| **PC21.** Describe techniques for image segmentation to separate objects or regions within an image. | - | - | - | - |
| **PC22.** Discuss image augmentation techniques to improve model generalization and performance on visual tasks. | - | - | - | - |
| **PC23.** Explain the principles of object tracking and motion detection in video processing. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC24.** Understand feature extraction methods like SIFT, SURF, and ORB for object recognition and computer vision applications. | - | - | - | - |
| *Fundamentals of Internet of Things (IoT)* | **6** | **8** | **-** | **1** |
| **PC25.** Understand the basic architecture of IoT systems, including sensors, actuators, and communication protocols. | - | - | - | - |
| **PC26.** Explain to connect and configure IoT devices for data collection and monitoring. | - | - | - | - |
| **PC27.** Explain the role of edge computing and its integration with IoT to process data locally for faster responses. | - | - | - | - |
| **PC28.** Understand the principles of IoT communication protocols such as MQTT, CoAP, and HTTP, and their applications. | - | - | - | - |
| **PC29.** Describe data security and privacy concerns in IoT systems, including encryption and authentication techniques. | - | - | - | - |
| **PC30.** Describe IoT for smart systems design, such as smart homes, industrial automation, or environmental monitoring. | - | - | - | - |
| *Basics of Robotics* | **7** | **8** | **-** | **2** |
| **PC31.** Explain the fundamental concepts of robot kinematics, including forward and inverse kinematics for robot movement and positioning. | - | - | - | - |
| **PC32.** Understand the programming robot control systems for tasks such as navigation, manipulation, and automation. | - | - | - | - |
| **PC33.** Discuss sensor integration (e.g., cameras, LIDAR, ultrasonic sensors) for robot perception and environment interaction. | - | - | - | - |
| **PC34.** Understand the basics of robot dynamics and forces and torques affect robot motion and stability. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC35.** Understand ability to implement robot path planning algorithms to enable autonomous navigation in dynamic environments. | - | - | - | - |
| **PC36.** Discuss robotic learning techniques, such as reinforcement learning, to improve robot decision-making and task execution. | - | - | - | - |
| **NOS Total** | **40** | **50** | **-** | **10** |

## National Occupational Standards (NOS) Parameters

| | |
|---|---|
| **NOS Code** | ICE/ITS/N0203 |
| **NOS Name** | Building Blocks of Artificial Intelligence (A.I) |
| **Sector** | Information Technology Sector |
| **Sub-Sector** | |
| **Occupation** | Artificial Intelligence |
| **NSQF Level** | 5 |
| **Credits** | 3 |
| **Version** | 1.0 |
| **Last Reviewed Date** | 17/12/2024 |
| **Next Review Date** | 17/12/2027 |
| **NSQC Clearance Date** | 17/12/2024 |

# DGT/VSQ/N0102: Employability Skills (60 Hours)

## Description

This unit is about employability skills, Constitutional values, becoming a professional in the 21st Century, digital, financial, and legal literacy, diversity and Inclusion, English and communication skills, customer service, entrepreneurship, and apprenticeship, getting ready for jobs and career development.

## Scope

The scope covers the following :

- Introduction to Employability Skills
- Constitutional values - Citizenship
- Becoming a Professional in the 21st Century
- Basic English Skills
- Career Development & Goal Setting
- Communication Skills
- Diversity & Inclusion
- Financial and Legal Literacy
- Essential Digital Skills
- Entrepreneurship
- Customer Service
- Getting ready for Apprenticeship & Jobs

## Elements and Performance Criteria

*Introduction to Employability Skills*

To be competent, the user/individual on the job must be able to:

**PC1.** identify employability skills required for jobs in various industries

**PC2.** identify and explore learning and employability portals

*Constitutional values – Citizenship*

To be competent, the user/individual on the job must be able to:

**PC3.** recognize the significance of constitutional values, including civic rights and duties, citizenship, responsibility towards society etc. and personal values and ethics such as honesty, integrity, caring and respecting others, etc.

**PC4.** follow environmentally sustainable practices

*Becoming a Professional in the 21st Century*

To be competent, the user/individual on the job must be able to:

**PC5.** recognize the significance of 21st Century Skills for employment

**PC6.** practice the 21st Century Skills such as Self-Awareness, Behaviour Skills, time management, critical and adaptive thinking, problem-solving, creative thinking, social and cultural awareness, emotional awareness, learning to learn for continuous learning etc. in personal and professional life

*Basic English Skills*

To be competent, the user/individual on the job must be able to:

**PC7.** use basic English for everyday conversation in different contexts, in person and over the telephone

**PC8.** read and understand routine information, notes, instructions, mails, letters etc. written in English

**PC9.** write short messages, notes, letters, e-mails etc. in English

*Career Development & Goal Setting*

To be competent, the user/individual on the job must be able to:

**PC10.** understand the difference between job and career

**PC11.** prepare a career development plan with short- and long-term goals, based on aptitude

*Communication Skills*

To be competent, the user/individual on the job must be able to:

**PC12.** follow verbal and non-verbal communication etiquette and active listening techniques in various settings

**PC13.** work collaboratively with others in a team

*Diversity & Inclusion*

To be competent, the user/individual on the job must be able to:

**PC14.** communicate and behave appropriately with all genders and PwD

**PC15.** escalate any issues related to sexual harassment at workplace according to POSH Act

*Financial and Legal Literacy*

To be competent, the user/individual on the job must be able to:

**PC16.** select financial institutions, products and services as per requirement

**PC17.** carry out offline and online financial transactions, safely and securely

**PC18.** identify common components of salary and compute income, expenses, taxes, investments etc

**PC19.** identify relevant rights and laws and use legal aids to fight against legal exploitation

*Essential Digital Skills*

To be competent, the user/individual on the job must be able to:

**PC20.** operate digital devices and carry out basic internet operations securely and safely

**PC21.** use e- mail and social media platforms and virtual collaboration tools to work effectively

**PC22.** use basic features of word processor, spreadsheets, and presentations

*Entrepreneurship*

To be competent, the user/individual on the job must be able to:

**PC23.** identify different types of Entrepreneurship and Enterprises and assess opportunities for potential business through research

**PC24.** develop a business plan and a work model, considering the 4Ps of Marketing Product, Price, Place and Promotion

**PC25.** identify sources of funding, anticipate, and mitigate any financial/ legal hurdles for the potential business opportunity

*Customer Service*

To be competent, the user/individual on the job must be able to:

**PC26.** identify different types of customers

**PC27.** identify and respond to customer requests and needs in a professional manner.

**PC28.** follow appropriate hygiene and grooming standards

*Getting ready for apprenticeship & Jobs*

To be competent, the user/individual on the job must be able to:

**PC29.** create a professional Curriculum vitae (Résumé)

**PC30.** search for suitable jobs using reliable offline and online sources such as Employment exchange, recruitment agencies, newspapers etc. and job portals, respectively

**PC31.** apply to identified job openings using offline /online methods as per requirement

**PC32.** answer questions politely, with clarity and confidence, during recruitment and selection

**PC33.** identify apprenticeship opportunities and register for it as per guidelines and requirements

## Knowledge and Understanding (KU)

The individual on the job needs to know and understand:

**KU1.** need for employability skills and different learning and employability related portals

**KU2.** various constitutional and personal values

**KU3.** different environmentally sustainable practices and their importance

**KU4.** Twenty first (21st) century skills and their importance

**KU5.** how to use English language for effective verbal (face to face and telephonic) and written communication in formal and informal set up

**KU6.** importance of career development and setting long- and short-term goals

**KU7.** about effective communication

**KU8.** POSH Act

**KU9.** Gender sensitivity and inclusivity

**KU10.** different types of financial institutes, products, and services

**KU11.** how to compute income and expenditure

**KU12.** importance of maintaining safety and security in offline and online financial transactions

**KU13.** different legal rights and laws

**KU14.** different types of digital devices and the procedure to operate them safely and securely

**KU15.** how to create and operate an e- mail account and use applications such as word processors, spreadsheets etc.

**KU16.** how to identify business opportunities

**KU17.** types and needs of customers

**KU18.** how to apply for a job and prepare for an interview

**KU19.** apprenticeship scheme and the process of registering on apprenticeship portal

## Generic Skills (GS)

User/individual on the job needs to know how to:

**GS1.** read and write different types of documents/instructions/correspondence

**GS2.** communicate effectively using appropriate language in formal and informal settings

**GS3.** behave politely and appropriately with all
**GS4.** how to work in a virtual mode
**GS5.** perform calculations efficiently
**GS6.** solve problems effectively
**GS7.** pay attention to details
**GS8.** manage time efficiently
**GS9.** maintain hygiene and sanitization to avoid infection

## Assessment Criteria

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| *Introduction to Employability Skills* | **1** | **1** | **-** | **-** |
| **PC1.** identify employability skills required for jobs in various industries | - | - | - | - |
| **PC2.** identify and explore learning and employability portals | - | - | - | - |
| *Constitutional values – Citizenship* | **1** | **1** | **-** | **-** |
| **PC3.** recognize the significance of constitutional values, including civic rights and duties, citizenship, responsibility towards society etc. and personal values and ethics such as honesty, integrity, caring and respecting others, etc. | - | - | - | - |
| **PC4.** follow environmentally sustainable practices | - | - | - | - |
| *Becoming a Professional in the 21st Century* | **2** | **4** | **-** | **-** |
| **PC5.** recognize the significance of 21st Century Skills for employment | - | - | - | - |
| **PC6.** practice the 21st Century Skills such as Self-Awareness, Behaviour Skills, time management, critical and adaptive thinking, problem-solving, creative thinking, social and cultural awareness, emotional awareness, learning to learn for continuous learning etc. in personal and professional life | - | - | - | - |
| *Basic English Skills* | **2** | **3** | **-** | **-** |
| **PC7.** use basic English for everyday conversation in different contexts, in person and over the telephone | - | - | - | - |
| **PC8.** read and understand routine information, notes, instructions, mails, letters etc. written in English | - | - | - | - |
| **PC9.** write short messages, notes, letters, e-mails etc. in English | - | - | - | - |
| *Career Development & Goal Setting* | **1** | **2** | **-** | **-** |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC10.** understand the difference between job and career | - | - | - | - |
| **PC11.** prepare a career development plan with short- and long-term goals, based on aptitude | - | - | - | - |
| *Communication Skills* | **2** | **2** | **-** | **-** |
| **PC12.** follow verbal and non-verbal communication etiquette and active listening techniques in various settings | - | - | - | - |
| **PC13.** work collaboratively with others in a team | - | - | - | - |
| *Diversity & Inclusion* | **1** | **2** | **-** | **-** |
| **PC14.** communicate and behave appropriately with all genders and PwD | - | - | - | - |
| **PC15.** escalate any issues related to sexual harassment at workplace according to POSH Act | - | - | - | - |
| *Financial and Legal Literacy* | **2** | **3** | **-** | **-** |
| **PC16.** select financial institutions, products and services as per requirement | - | - | - | - |
| **PC17.** carry out offline and online financial transactions, safely and securely | - | - | - | - |
| **PC18.** identify common components of salary and compute income, expenses, taxes, investments etc | - | - | - | - |
| **PC19.** identify relevant rights and laws and use legal aids to fight against legal exploitation | - | - | - | - |
| *Essential Digital Skills* | **3** | **4** | **-** | **-** |
| **PC20.** operate digital devices and carry out basic internet operations securely and safely | - | - | - | - |
| **PC21.** use e- mail and social media platforms and virtual collaboration tools to work effectively | - | - | - | - |
| **PC22.** use basic features of word processor, spreadsheets, and presentations | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| *Entrepreneurship* | **2** | **3** | **-** | **-** |
| **PC23.** identify different types of Entrepreneurship and Enterprises and assess opportunities for potential business through research | - | - | - | - |
| **PC24.** develop a business plan and a work model, considering the 4Ps of Marketing Product, Price, Place and Promotion | - | - | - | - |
| **PC25.** identify sources of funding, anticipate, and mitigate any financial/ legal hurdles for the potential business opportunity | - | - | - | - |
| *Customer Service* | **1** | **2** | **-** | **-** |
| **PC26.** identify different types of customers | - | - | - | - |
| **PC27.** identify and respond to customer requests and needs in a professional manner. | - | - | - | - |
| **PC28.** follow appropriate hygiene and grooming standards | - | - | - | - |
| *Getting ready for apprenticeship & Jobs* | **2** | **3** | **-** | **-** |
| **PC29.** create a professional Curriculum vitae (Résumé) | - | - | - | - |
| **PC30.** search for suitable jobs using reliable offline and online sources such as Employment exchange, recruitment agencies, newspapers etc. and job portals, respectively | - | - | - | - |
| **PC31.** apply to identified job openings using offline /online methods as per requirement | - | - | - | - |
| **PC32.** answer questions politely, with clarity and confidence, during recruitment and selection | - | - | - | - |
| **PC33.** identify apprenticeship opportunities and register for it as per guidelines and requirements | - | - | - | - |
| **NOS Total** | **20** | **30** | **-** | **-** |

## National Occupational Standards (NOS) Parameters

| | |
|---|---|
| **NOS Code** | DGT/VSQ/N0102 |
| **NOS Name** | Employability Skills (60 Hours) |
| **Sector** | Cross Sectoral |
| **Sub-Sector** | Professional Skills |
| **Occupation** | Employability |
| **NSQF Level** | 4 |
| **Credits** | 2 |
| **Version** | 1.0 |
| **Last Reviewed Date** | 22/10/2024 |
| **Next Review Date** | 22/10/2027 |
| **NSQC Clearance Date** | 22/10/2024 |

# ICE/ITS/N0204: Applications of AI tools/algorithms in Computer Science and Information Technology Engineering

## Description

Fundamentals of AI Specializations in Computer Science and Information Technology Engineering focus on the core principles of AI methodologies, encompassing practical applications of tools and algorithms in various domains. The program integrates theoretical knowledge with hands-on experience to equip learners for designing and implementing AI solutions.

## Scope

The scope covers the following :

- Encompasses applications in software development, cybersecurity, cloud computing, and IoT.
- Prepares professionals to optimize processes and enhance decision-making.
- Promotes innovation through the use of AI solutions.

## Elements and Performance Criteria

*Use AI tools/algorithms Business Intelligence and Data Analysis*

To be competent, the user/individual on the job must be able to:

**PC1.** Understand the ability to integrate diverse data sources using AI tools to create a unified dataset for comprehensive business intelligence and analysis.

**PC2.** Describe machine learning algorithms to develop predictive models that forecast business trends, customer behavior, and market dynamics for informed decision-making.

**PC3.** Understand to use AI-powered visualization tools to create interactive dashboards and reports that effectively communicate insights derived from data analysis to stakeholders.

**PC4.** Discuss NLP techniques to analyze unstructured data (e.g., customer reviews, social media interactions) for sentiment analysis and deriving actionable business insights.

**PC5.** Describe AI algorithms for anomaly detection to identify unusual patterns in data, aiding in fraud detection, risk management, and ensuring data quality in business processes.

**PC6.** Understand AI-driven optimization techniques to enhance business processes, improve operational efficiency, and reduce costs through data-informed strategies and recommendations.

*Utilize AI tools/algorithms in Software Development Engineering*

To be competent, the user/individual on the job must be able to:

**PC7.** Understand AI-driven code completion tools to suggest code snippets and functions as developer’s type, enhancing productivity and reducing the likelihood of syntax errors.

**PC8.** Discuss AI algorithms to create and execute automated test cases, facilitating regression testing and ensuring software reliability through continuous integration and deployment practices

**PC9.** Describe machine learning techniques to identify patterns in code that lead to bugs, enabling predictive maintenance and automatic bug fixing to improve software quality

**PC10.** Discuss AI tools to analyze application performance data and recommend optimizations, such as memory usage reduction and processing speed improvements, to enhance software efficiency.

**PC11.** Understand AI algorithms to analyze user interaction data with software applications, allowing for data-driven enhancements in user experience (UX) design and feature development.

*Utilize AI tools/algorithms in Cyber security*

To be competent, the user/individual on the job must be able to:

**PC12.** Understand AI-driven threat detection systems that analyze network traffic and user behavior to identify potential security breaches in real time, enabling rapid incident response.

**PC13.** Utilize machine learning algorithms to establish baseline behavior for users and systems, allowing for the identification of anomalies to indicate cyber threats or malicious activity.

**PC14.** Discuss natural language processing (NLP) techniques to analyze email content and metadata, accurately identifying and flagging potential phishing attempts before reaching users.

**PC15.** Describe AI-based biometric authentication methods, such as facial recognition and behavioral biometrics to enhance security protocols and reduce the risk of unauthorized access.

**PC16.** Understand predictive analytics to forecast potential cybersecurity incidents based on historical data, enabling organizations to strengthen their defenses and improve incident response planning.

*Use AI tools/algorithms in IoT and Edge Computing*

To be competent, the user/individual on the job must be able to:

**PC17.** Understand to utilize AI algorithms at the edge to process and analyze data from IoT devices in real time, enabling quicker decision-making and reducing latency in critical applications.

**PC18.** Describe machine learning models to analyze data from IoT sensors, predicting equipment failures and enabling proactive maintenance, minimizing downtime and maintenance costs.

**PC19.** Discuss AI tools to optimize energy consumption in IoT devices and edge computing environments by analyzing usage patterns and adjusting configurations accordingly.

**PC20.** Describe AI-driven anomaly detection techniques to monitor IoT device behavior, identifying unusual patterns that may indicate security threats or malfunctions.

**PC21.** Understand AI algorithms to filter and prioritize data collected from IoT devices before transmitting it to the cloud, ensuring reducing bandwidth usage.

**PC22.** Explain AI-powered analytics at the edge to derive insights from data generated by IoT devices, enabling local decision-making and reducing the need for constant cloud connectivity.

*Utilize AI tools/algorithms in Cloud Computing*

To be competent, the user/individual on the job must be able to:

**PC23.** Understand AI algorithms to dynamically allocate and manage cloud resources based on workload demands, improving efficiency and reducing operational costs through auto-scaling techniques.

**PC24.** Explain machine learning models to analyze usage patterns and predict future resource requirements, enabling proactive scaling and optimizing cloud resource utilization.

**PC25.** Discuss AI-driven security tools to monitor cloud environments for potential threats, automatically detecting anomalies and responding to security incidents in real time.

**PC26.** Describe AI algorithms to automate data classification, storage optimization, and retrieval processes in cloud environments, enhancing data accessibility and management efficiency.

**PC27.** Discuss AI tools to streamline practices by automating testing, deployment and monitoring tasks, accelerating the software development lifecycle and improving deployment reliability.

**PC28.** Explore AI-powered analytics to monitor cloud spending, providing insights and forecasts on usage patterns and costs, allowing organizations to optimize their cloud budgets and resource allocation.

*Advancement in AI for CS and IT*

To be competent, the user/individual on the job must be able to:

**PC29.** Explain research and development to create advanced AI algorithms to enhance computational efficiency and effectiveness, such as improved neural network architectures or optimization techniques.

**PC30.** Discuss AI solutions to modernize and enhance legacy IT systems, improving functionality and performance.

**PC31.** Understand to develop and deploys AI-powered decision support systems to assist organizations in making data-driven decisions by analyzing large datasets and providing actionable insights.

**PC32.** Explore the application of AI technologies across various fields such as healthcare, finance, and transportation, demonstrating versatility and adaptability in AI implementations within CS and IT.

## Knowledge and Understanding (KU)

The individual on the job needs to know and understand:

**KU1.** Popular AI frameworks and libraries (e.g., TensorFlow, PyTorch, and Scikit-learn) and their applications in developing machine learning models and neural networks.

**KU2.** Deploying AI models in production environments, including containerization (e.g., Docker) and orchestration tools (e.g., Kubernetes).

**KU3.** Integrate AI solutions with existing IT infrastructure and software applications to enhance functionality and performance.

**KU4.** Role of AI tools and algorithms in enhancing cybersecurity measures, including threat detection, anomaly detection, and incident response.

**KU5.** AI algorithms to be applied in Internet of Things (IoT) environments to analyze data from connected devices and enable intelligent decision-making.

**KU6.** Use of cloud computing platforms (e.g., AWS, Azure, Google Cloud) for scalable AI model training and deployment, including the benefits and challenges associated with cloud-based AI services.

**KU7.** Awareness of ethical issues related to AI applications, including bias, transparency, and accountability, and the importance of developing responsible AI systems.

## Generic Skills (GS)

User/individual on the job needs to know how to:

**GS1.** Listen and communicate effectively and accurately.
**GS2.** Apply problem-solving approaches for different situations.
**GS3.** Work effectively in a team.
**GS4.** Employ proper time management.
**GS5.** Plan and organize work.
**GS6.** Maintain hygiene and sanitation.
**GS7.** Analytical Skills.

## Assessment Criteria

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| *Use AI tools/algorithms Business Intelligence and Data Analysis* | 6 | 9 | - | 2 |
| **PC1.** Understand the ability to integrate diverse data sources using AI tools to create a unified dataset for comprehensive business intelligence and analysis. | - | - | - | - |
| **PC2.** Describe machine learning algorithms to develop predictive models that forecast business trends, customer behavior, and market dynamics for informed decision-making. | - | - | - | - |
| **PC3.** Understand to use AI-powered visualization tools to create interactive dashboards and reports that effectively communicate insights derived from data analysis to stakeholders. | - | - | - | - |
| **PC4.** Discuss NLP techniques to analyze unstructured data (e.g., customer reviews, social media interactions) for sentiment analysis and deriving actionable business insights. | - | - | - | - |
| **PC5.** Describe AI algorithms for anomaly detection to identify unusual patterns in data, aiding in fraud detection, risk management, and ensuring data quality in business processes. | - | - | - | - |
| **PC6.** Understand AI-driven optimization techniques to enhance business processes, improve operational efficiency, and reduce costs through data-informed strategies and recommendations. | - | - | - | - |
| *Utilize AI tools/algorithms in Software Development Engineering* | 6 | 9 | - | 2 |
| **PC7.** Understand AI-driven code completion tools to suggest code snippets and functions as developer’s type, enhancing productivity and reducing the likelihood of syntax errors. | - | - | - | - |
| **PC8.** Discuss AI algorithms to create and execute automated test cases, facilitating regression testing and ensuring software reliability through continuous integration and deployment practices | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC9.** Describe machine learning techniques to identify patterns in code that lead to bugs, enabling predictive maintenance and automatic bug fixing to improve software quality | - | - | - | - |
| **PC10.** Discuss AI tools to analyze application performance data and recommend optimizations, such as memory usage reduction and processing speed improvements, to enhance software efficiency. | - | - | - | - |
| **PC11.** Understand AI algorithms to analyze user interaction data with software applications, allowing for data-driven enhancements in user experience (UX) design and feature development. | - | - | - | - |
| *Utilize AI tools/algorithms in Cyber security* | **7** | **8** | **-** | **2** |
| **PC12.** Understand AI-driven threat detection systems that analyze network traffic and user behavior to identify potential security breaches in real time, enabling rapid incident response. | - | - | - | - |
| **PC13.** Utilize machine learning algorithms to establish baseline behavior for users and systems, allowing for the identification of anomalies to indicate cyber threats or malicious activity. | - | - | - | - |
| **PC14.** Discuss natural language processing (NLP) techniques to analyze email content and metadata, accurately identifying and flagging potential phishing attempts before reaching users. | - | - | - | - |
| **PC15.** Describe AI-based biometric authentication methods, such as facial recognition and behavioral biometrics to enhance security protocols and reduce the risk of unauthorized access. | - | - | - | - |
| **PC16.** Understand predictive analytics to forecast potential cybersecurity incidents based on historical data, enabling organizations to strengthen their defenses and improve incident response planning. | - | - | - | - |
| *Use AI tools/algorithms in IoT and Edge Computing* | **7** | **8** | **-** | **2** |
| **PC17.** Understand to utilize AI algorithms at the edge to process and analyze data from IoT devices in real time, enabling quicker decision-making and reducing latency in critical applications. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC18.** Describe machine learning models to analyze data from IoT sensors, predicting equipment failures and enabling proactive maintenance, minimizing downtime and maintenance costs. | - | - | - | - |
| **PC19.** Discuss AI tools to optimize energy consumption in IoT devices and edge computing environments by analyzing usage patterns and adjusting configurations accordingly. | - | - | - | - |
| **PC20.** Describe AI-driven anomaly detection techniques to monitor IoT device behavior, identifying unusual patterns that may indicate security threats or malfunctions. | - | - | - | - |
| **PC21.** Understand AI algorithms to filter and prioritize data collected from IoT devices before transmitting it to the cloud, ensuring reducing bandwidth usage. | - | - | - | - |
| **PC22.** Explain AI-powered analytics at the edge to derive insights from data generated by IoT devices, enabling local decision-making and reducing the need for constant cloud connectivity. | - | - | - | - |
| *Utilize AI tools/algorithms in Cloud Computing* | **7** | **8** | **-** | **1** |
| **PC23.** Understand AI algorithms to dynamically allocate and manage cloud resources based on workload demands, improving efficiency and reducing operational costs through auto-scaling techniques. | - | - | - | - |
| **PC24.** Explain machine learning models to analyze usage patterns and predict future resource requirements, enabling proactive scaling and optimizing cloud resource utilization. | - | - | - | - |
| **PC25.** Discuss AI-driven security tools to monitor cloud environments for potential threats, automatically detecting anomalies and responding to security incidents in real time. | - | - | - | - |
| **PC26.** Describe AI algorithms to automate data classification, storage optimization, and retrieval processes in cloud environments, enhancing data accessibility and management efficiency. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC27.** Discuss AI tools to streamline practices by automating testing, deployment and monitoring tasks, accelerating the software development lifecycle and improving deployment reliability. | - | - | - | - |
| **PC28.** Explore AI-powered analytics to monitor cloud spending, providing insights and forecasts on usage patterns and costs, allowing organizations to optimize their cloud budgets and resource allocation. | - | - | - | - |
| *Advancement in AI for CS and IT* | **7** | **8** | **-** | **1** |
| **PC29.** Explain research and development to create advanced AI algorithms to enhance computational efficiency and effectiveness, such as improved neural network architectures or optimization techniques. | - | - | - | - |
| **PC30.** Discuss AI solutions to modernize and enhance legacy IT systems, improving functionality and performance. | - | - | - | - |
| **PC31.** Understand to develop and deploys AI-powered decision support systems to assist organizations in making data-driven decisions by analyzing large datasets and providing actionable insights. | - | - | - | - |
| **PC32.** Explore the application of AI technologies across various fields such as healthcare, finance, and transportation, demonstrating versatility and adaptability in AI implementations within CS and IT. | - | - | - | - |
| **NOS Total** | **40** | **50** | **-** | **10** |

## National Occupational Standards (NOS) Parameters

| | |
|---|---|
| **NOS Code** | ICE/ITS/N0204 |
| **NOS Name** | Applications of AI tools/algorithms in Computer Science and Information Technology Engineering |
| **Sector** | Information Technology Sector |
| **Sub-Sector** | |
| **Occupation** | Artificial Intelligence |
| **NSQF Level** | 5 |
| **Credits** | 10 |
| **Version** | 1.0 |
| **Last Reviewed Date** | 17/12/2024 |
| **Next Review Date** | 17/12/2027 |
| **NSQC Clearance Date** | 17/12/2024 |

# ICE/ITS/N0205: Applications of AI tools/algorithms in Electronics & Communication Engineering

## Description

This course explores the integration of artificial intelligence (AI) techniques in Electronics and Communication Engineering (ECE) to enhance the performance, efficiency, and adaptability of modern electronic systems. It covers fundamental AI concepts, including machine learning, deep learning, and optimization algorithms, and their applications in signal processing, wireless communication, embedded systems, and circuit design. Through practical case studies and hands-on projects, students will learn to apply AI-driven data analysis, predictive modeling, and automation techniques to solve real-world challenges in ECE.

## Scope

The scope covers the following :

- Optimizes signal processing techniques.
- Enhances communication systems and network performance.
- Develops intelligent embedded systems for IoT applications.
- Drives advancements in wireless communication technologies.
- Contributes to autonomous systems and smart technologies.
- Responds to real-time data and user interactions.

## Elements and Performance Criteria

### *Utilize AI tools /algorithms in Signal Processing*

To be competent, the user/individual on the job must be able to:

**PC1.** Understand AI algorithms, such as adaptive filters, to enhance signal quality by dynamically adjusting filter parameters in response to varying noise levels and signal characteristics.

**PC2.** Explain machine learning techniques to automate the extraction of relevant features from complex signals, improving the performance of signal classification and analysis tasks.

**PC3.** Discuss deep learning models for noise reduction in signals, enhancing the clarity and quality of audio and communication systems by effectively separating signal from noise.

**PC4.** Describe AI techniques to classify different modulation schemes in communication signals, facilitating improved spectrum management and efficient signal processing.

**PC5.** Discuss AI-driven tools to perform real-time analysis of signals, enabling immediate detection of anomalies and events in various applications such as telecommunications and radar systems.

**PC6.** Understand predictive analytics powered by AI to monitor the health of signal processing equipment, forecasting potential failures and enabling timely maintenance to minimize downtime.

### *Use AI tools /algorithms in Communication Systems*

To be competent, the user/individual on the job must be able to:

**PC7.** Understand AI algorithms to improve channel estimation and equalization techniques in communication systems, enhancing signal integrity and reducing interference in varying channel conditions.

**PC8.** Discuss AI-driven strategies for dynamic resource allocation in communication networks, optimizing bandwidth usage and improving overall network efficiency based on real-time traffic demands.

**PC9.** Describe machine learning algorithms to develop intelligent routing protocols that optimize data paths in communication networks, reducing latency and improving data throughput.

**PC10.** Explore AI techniques to monitor and manage QoS parameters in communication systems, ensuring optimal performance by dynamically adjusting network resources based on user requirements.

**PC11.** Discuss AI tools to detect and respond to security threats in communication systems, employing anomaly detection and intrusion prevention techniques to safeguard data integrity and confidentiality.

**PC12.** Understand AI algorithms into signal processing chains for communication systems, enabling to enhance signal robustness and clarity.

*Use AI tools /algorithms in Embedded Systems and IoT*

To be competent, the user/individual on the job must be able to:

**PC13.** Explore AI algorithms to process and analyze data from smart sensors in embedded systems, enabling real-time decision-making and automation in various IoT applications.

**PC14.** Understand machine learning techniques to optimize energy consumption in embedded devices, improving battery life and performance in IoT applications through adaptive power management.

**PC15.** Discuss AI-driven predictive analytics in embedded systems to monitor device performance and predict failures, facilitating proactive maintenance and reducing downtime in IoT networks.

**PC16.** Describe AI algorithms for efficient data compression in IoT devices, ensuring reduced bandwidth usage and faster data transmission without compromising data integrity.

**PC17.** Discuss AI tools to detect anomalies in IoT data streams, enhancing security and reliability by identifying unusual patterns that may indicate faults or security breaches in embedded systems.

**PC18.** Understand AI algorithms into embedded control systems, enabling adaptive and intelligent control mechanisms for IoT devices, improving responsiveness and functionality in dynamic environments.

*Utilize AI tools /algorithms in VLSI Design and Hardware Optimization*

To be competent, the user/individual on the job must be able to:

**PC19.** Discuss AI algorithms to automate the circuit design process, enabling faster design iterations and improved accuracy in VLSI layout generation.

**PC20.** Explain machine learning techniques for efficient design rule checking in VLSI designs, ensuring compliance with manufacturing specifications and reducing errors in fabrication.

**PC21.** Describe AI-driven strategies to optimize power consumption in VLSI circuits, enhancing energy efficiency through adaptive voltage and frequency scaling based on workload requirements.

**PC22.** Discuss predictive analytics powered by AI to forecast the performance of VLSI designs, allowing designers to make informed decisions during the design process and identify potential bottlenecks.

**PC23.** Understand AI algorithms for fault detection and diagnosis in VLSI circuits, enhancing reliability by identifying and mitigating issues early in the design and manufacturing process.

**PC24.** Explain AI tools to optimize the physical layout of VLSI components, improving area efficiency and signal integrity while minimizing crosstalk and delays in high-density designs.

*Use AI tools /algorithms in Robotics and Autonomous Systems*

To be competent, the user/individual on the job must be able to:

**PC25.** Understand AI algorithms for efficient path planning and navigation in autonomous robots, enabling them to navigate complex environments and avoid obstacles in real-time.

**PC26.** Discuss machine learning techniques to integrate data from multiple sensors (e.g., cameras, LiDAR, and IMUs) in robotics.

**PC27.** Describe AI-driven decision-making algorithms in autonomous systems, allowing robots to analyze situations, assess risks, and make informed choices based on dynamic conditions.

**PC28.** Discuss natural language processing (NLP) and computer vision algorithms to facilitate intuitive human-robot interaction.

**PC29.** Discuss AI tools to develop robust control systems in robotics, ensuring stability and performance under varying operational conditions and disturbances.

**PC30.** Understand reinforcement learning techniques to enable robots to learn and improve their skills through trial and error.

*Utilize AI tools /algorithms in Wireless Communication and Network Optimization*

To be competent, the user/individual on the job must be able to:

**PC31.** Understand AI algorithms to dynamically allocate and manage spectrum resources in wireless communication, optimizing frequency usage and minimizing interference among users.

**PC32.** Discuss machine learning techniques to predict network traffic patterns, enabling proactive management of network resources and improving overall performance during peak usage times.

**PC33.** Describe AI-driven methods to enhance QoS in wireless networks, adjusting parameters such as bandwidth allocation and latency management based on real-time performance metrics.

**PC34.** Discuss AI tools to implement adaptive modulation and coding schemes in wireless communication, optimizing data transmission rates according to channel conditions.

**PC35.** Explain AI algorithms to detect anomalies in wireless network traffic, facilitating rapid identification of security threats or performance issues and enabling timely interventions.

**PC36.** Explore AI techniques to optimize energy consumption in wireless communication systems, enhancing battery life in devices and reducing overall energy costs while maintaining performance.

*Use AI tools /algorithms in Electronic System Design and Optimization*

To be competent, the user/individual on the job must be able to:

**PC37.** Understand AI algorithms to automatically verify design rules in electronic circuit layouts, ensuring compliance with industry standards and reducing errors in the manufacturing process.

**PC38.** Describe machine learning techniques to enhance the speed and accuracy of circuit simulations, allowing designers to predict system behavior under various conditions and optimize designs more effectively.

**PC39.** Discuss AI-driven optimization methods for effective resource allocation in electronic systems, improving performance while minimizing costs and material usage throughout the design process.

**PC40.** Understand AI tools to optimize the physical layout of electronic components on printed circuit boards (PCBs), enhancing signal integrity, reducing electromagnetic interference, and improving overall circuit performance.

### *Advancement in AI for ECE*

To be competent, the user/individual on the job must be able to:

**PC41.** Discuss of advanced machine learning algorithms tailored for ECE applications, such as convolutional neural networks (CNNs) for image processing in computer vision and recurrent neural networks (RNNs) for time-series analysis in signal processing.

**PC42.** Understand AI to optimize the design and management of 5G networks and future wireless communication systems, reducing latency, and enhancing overall network performance.

**PC43.** Discuss advancements in AI-driven smart antenna technologies, enabling adaptive beamforming and spatial multiplexing to enhance signal quality and capacity in wireless communications.

**PC44.** Understand AI algorithms for real-time decision-making in robotics, allowing for improved navigation, obstacle avoidance and task execution in complex environments.

**PC45.** Discuss AI techniques for real-time fault detection and diagnosis in electronic systems, improving reliability and reducing maintenance costs through predictive maintenance strategies.

**PC46.** Decribe advancements in integrating AI with IoT devices for intelligent data processing and decision-making, allowing for smarter and more efficient communication in smart cities, healthcare and industrial applications.

## Knowledge and Understanding (KU)

The individual on the job needs to know and understand:

**KU1.** Basic AI concepts, including machine learning, deep learning, and neural networks, and their relevance to electronics and communication systems.

**KU2.** AI algorithms enhance signal processing techniques, enabling improved noise reduction, signal classification, and data interpretation in communication systems.

**KU3.** AI-based methods for optimizing network performance, including traffic prediction, load balancing, and resource allocation in communication networks.

**KU4.** AI tools into embedded systems, enabling intelligent decision-making and automation in various electronic devices.

**KU5.** AI algorithms are applied in robotics for navigation, path planning, and task execution, enhancing the functionality of autonomous systems.

**KU6.** Role of AI in predictive maintenance, allowing for real-time monitoring and analysis of electronic systems to anticipate failures and reduce downtime.

**KU7.** AI applications that enhance communication systems, such as adaptive modulation techniques and error correction algorithms.

**KU8.** AI tools facilitate data-driven decision-making processes in electronic and communication engineering, allowing for real-time adjustments based on data analysis.

**KU9.** Application of AI in IoT frameworks, enhancing data collection, processing and analytics for smarter devices and systems.

## Generic Skills (GS)

User/individual on the job needs to know how to:

**GS1.** Listen and communicate effectively and accurately.
**GS2.** Apply problem-solving approaches for different situations.
**GS3.** Work effectively in a team.
**GS4.** Employ proper time management.
**GS5.** Plan and organize work.
**GS6.** Maintain hygiene and sanitation.
**GS7.** Analytical Skills.

## Assessment Criteria

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| *Utilize AI tools /algorithms in Signal Processing* | **5** | **6** | **-** | **2** |
| **PC1.** Understand AI algorithms, such as adaptive filters, to enhance signal quality by dynamically adjusting filter parameters in response to varying noise levels and signal characteristics. | - | - | - | - |
| **PC2.** Explain machine learning techniques to automate the extraction of relevant features from complex signals, improving the performance of signal classification and analysis tasks. | - | - | - | - |
| **PC3.** Discuss deep learning models for noise reduction in signals, enhancing the clarity and quality of audio and communication systems by effectively separating signal from noise. | - | - | - | - |
| **PC4.** Describe AI techniques to classify different modulation schemes in communication signals, facilitating improved spectrum management and efficient signal processing. | - | - | - | - |
| **PC5.** Discuss AI-driven tools to perform real-time analysis of signals, enabling immediate detection of anomalies and events in various applications such as telecommunications and radar systems. | - | - | - | - |
| **PC6.** Understand predictive analytics powered by AI to monitor the health of signal processing equipment, forecasting potential failures and enabling timely maintenance to minimize downtime. | - | - | - | - |
| *Use AI tools /algorithms in Communication Systems* | **5** | **6** | **-** | **2** |
| **PC7.** Understand AI algorithms to improve channel estimation and equalization techniques in communication systems, enhancing signal integrity and reducing interference in varying channel conditions. | - | - | - | - |
| **PC8.** Discuss AI-driven strategies for dynamic resource allocation in communication networks, optimizing bandwidth usage and improving overall network efficiency based on real-time traffic demands. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC9.** Describe machine learning algorithms to develop intelligent routing protocols that optimize data paths in communication networks, reducing latency and improving data throughput. | - | - | - | - |
| **PC10.** Explore AI techniques to monitor and manage QoS parameters in communication systems, ensuring optimal performance by dynamically adjusting network resources based on user requirements. | - | - | - | - |
| **PC11.** Discuss AI tools to detect and respond to security threats in communication systems, employing anomaly detection and intrusion prevention techniques to safeguard data integrity and confidentiality. | - | - | - | - |
| **PC12.** Understand AI algorithms into signal processing chains for communication systems, enabling to enhance signal robustness and clarity. | - | - | - | - |
| *Use AI tools /algorithms in Embedded Systems and IoT* | **5** | **6** | **-** | **1** |
| **PC13.** Explore AI algorithms to process and analyze data from smart sensors in embedded systems, enabling real-time decision-making and automation in various IoT applications. | - | - | - | - |
| **PC14.** Understand machine learning techniques to optimize energy consumption in embedded devices, improving battery life and performance in IoT applications through adaptive power management. | - | - | - | - |
| **PC15.** Discuss AI-driven predictive analytics in embedded systems to monitor device performance and predict failures, facilitating proactive maintenance and reducing downtime in IoT networks. | - | - | - | - |
| **PC16.** Describe AI algorithms for efficient data compression in IoT devices, ensuring reduced bandwidth usage and faster data transmission without compromising data integrity. | - | - | - | - |
| **PC17.** Discuss AI tools to detect anomalies in IoT data streams, enhancing security and reliability by identifying unusual patterns that may indicate faults or security breaches in embedded systems. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC18.** Understand AI algorithms into embedded control systems, enabling adaptive and intelligent control mechanisms for IoT devices, improving responsiveness and functionality in dynamic environments. | - | - | - | - |
| *Utilize AI tools /algorithms in VLSI Design and Hardware Optimization* | **5** | **6** | **-** | **1** |
| **PC19.** Discuss AI algorithms to automate the circuit design process, enabling faster design iterations and improved accuracy in VLSI layout generation. | - | - | - | - |
| **PC20.** Explain machine learning techniques for efficient design rule checking in VLSI designs, ensuring compliance with manufacturing specifications and reducing errors in fabrication. | - | - | - | - |
| **PC21.** Describe AI-driven strategies to optimize power consumption in VLSI circuits, enhancing energy efficiency through adaptive voltage and frequency scaling based on workload requirements. | - | - | - | - |
| **PC22.** Discuss predictive analytics powered by AI to forecast the performance of VLSI designs, allowing designers to make informed decisions during the design process and identify potential bottlenecks. | - | - | - | - |
| **PC23.** Understand AI algorithms for fault detection and diagnosis in VLSI circuits, enhancing reliability by identifying and mitigating issues early in the design and manufacturing process. | - | - | - | - |
| **PC24.** Explain AI tools to optimize the physical layout of VLSI components, improving area efficiency and signal integrity while minimizing crosstalk and delays in high-density designs. | - | - | - | - |
| *Use AI tools /algorithms in Robotics and Autonomous Systems* | **5** | **6** | **-** | **1** |
| **PC25.** Understand AI algorithms for efficient path planning and navigation in autonomous robots, enabling them to navigate complex environments and avoid obstacles in real-time. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC26.** Discuss machine learning techniques to integrate data from multiple sensors (e.g., cameras, LiDAR, and IMUs) in robotics. | - | - | - | - |
| **PC27.** Describe AI-driven decision-making algorithms in autonomous systems, allowing robots to analyze situations, assess risks, and make informed choices based on dynamic conditions. | - | - | - | - |
| **PC28.** Discuss natural language processing (NLP) and computer vision algorithms to facilitate intuitive human-robot interaction. | - | - | - | - |
| **PC29.** Discuss AI tools to develop robust control systems in robotics, ensuring stability and performance under varying operational conditions and disturbances. | - | - | - | - |
| **PC30.** Understand reinforcement learning techniques to enable robots to learn and improve their skills through trial and error. | - | - | - | - |
| *Utilize AI tools /algorithms in Wireless Communication and Network Optimization* | **5** | **7** | **-** | **1** |
| **PC31.** Understand AI algorithms to dynamically allocate and manage spectrum resources in wireless communication, optimizing frequency usage and minimizing interference among users. | - | - | - | - |
| **PC32.** Discuss machine learning techniques to predict network traffic patterns, enabling proactive management of network resources and improving overall performance during peak usage times. | - | - | - | - |
| **PC33.** Describe AI-driven methods to enhance QoS in wireless networks, adjusting parameters such as bandwidth allocation and latency management based on real-time performance metrics. | - | - | - | - |
| **PC34.** Discuss AI tools to implement adaptive modulation and coding schemes in wireless communication, optimizing data transmission rates according to channel conditions. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC35.** Explain AI algorithms to detect anomalies in wireless network traffic, facilitating rapid identification of security threats or performance issues and enabling timely interventions. | - | - | - | - |
| **PC36.** Explore AI techniques to optimize energy consumption in wireless communication systems, enhancing battery life in devices and reducing overall energy costs while maintaining performance. | - | - | - | - |
| *Use AI tools /algorithms in Electronic System Design and Optimization* | **5** | **7** | **-** | **1** |
| **PC37.** Understand AI algorithms to automatically verify design rules in electronic circuit layouts, ensuring compliance with industry standards and reducing errors in the manufacturing process. | - | - | - | - |
| **PC38.** Describe machine learning techniques to enhance the speed and accuracy of circuit simulations, allowing designers to predict system behavior under various conditions and optimize designs more effectively. | - | - | - | - |
| **PC39.** Discuss AI-driven optimization methods for effective resource allocation in electronic systems, improving performance while minimizing costs and material usage throughout the design process. | - | - | - | - |
| **PC40.** Understand AI tools to optimize the physical layout of electronic components on printed circuit boards (PCBs), enhancing signal integrity, reducing electromagnetic interference, and improving overall circuit performance. | - | - | - | - |
| *Advancement in AI for ECE* | **5** | **6** | **-** | **1** |
| **PC41.** Discuss of advanced machine learning algorithms tailored for ECE applications, such as convolutional neural networks (CNNs) for image processing in computer vision and recurrent neural networks (RNNs) for time-series analysis in signal processing. | - | - | - | - |
| **PC42.** Understand AI to optimize the design and management of 5G networks and future wireless communication systems, reducing latency, and enhancing overall network performance. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC43.** Discuss advancements in AI-driven smart antenna technologies, enabling adaptive beamforming and spatial multiplexing to enhance signal quality and capacity in wireless communications. | - | - | - | - |
| **PC44.** Understand AI algorithms for real-time decision-making in robotics, allowing for improved navigation, obstacle avoidance and task execution in complex environments. | - | - | - | - |
| **PC45.** Discuss AI techniques for real-time fault detection and diagnosis in electronic systems, improving reliability and reducing maintenance costs through predictive maintenance strategies. | - | - | - | - |
| **PC46.** Decribe advancements in integrating AI with IoT devices for intelligent data processing and decision-making, allowing for smarter and more efficient communication in smart cities, healthcare and industrial applications. | - | - | - | - |
| **NOS Total** | **40** | **50** | **-** | **10** |

## National Occupational Standards (NOS) Parameters

| | |
|---|---|
| **NOS Code** | ICE/ITS/N0205 |
| **NOS Name** | Applications of AI tools/algorithms in Electronics & Communication Engineering |
| **Sector** | Information Technology Sector |
| **Sub-Sector** | |
| **Occupation** | Artificial Intelligence |
| **NSQF Level** | 5 |
| **Credits** | 10 |
| **Version** | 1.0 |
| **Last Reviewed Date** | 17/12/2024 |
| **Next Review Date** | 17/12/2027 |
| **NSQC Clearance Date** | 17/12/2024 |

# ICE/ITS/N0206: Applications of AI tools/algorithms in Electrical Engineering

## Description

This module will equip learners with the application of AI tools and algorithms in Electrical Engineering to improve the design, efficiency, and reliability of systems across various domains, such as power generation, control systems, and smart grids.

## Scope

The scope covers the following :

- Encompasses renewable energy systems and their optimization.
- Focuses on automation and control in electrical circuits.
- Involves predictive maintenance to prevent equipment failures.
- Aims to develop intelligent devices that adapt to user needs.
- Promotes increased efficiency and sustainability in electrical engineering practices.

## Elements and Performance Criteria

*Utilize AI tools /algorithms in Power Systems and Smart Grids*

To be competent, the user/individual on the job must be able to:

**PC1.** Understand AI algorithms for accurate real-time load forecasting in power systems, enabling better demand response and resource allocation to enhance grid reliability and efficiency.

**PC2.** Discuss AI-driven techniques for automated fault detection and diagnosis in power systems, improving the speed and accuracy of identifying issues and minimizing downtime.

**PC3.** Describe machine learning models to optimize the operation of smart grids, enhancing energy distribution, reducing losses, and integrating renewable energy sources effectively.

**PC4.** Explore AI tools in energy management systems to analyze consumption patterns, optimize energy usage and implement demand-side management strategies for residential and industrial application.

**PC5.** Understand AI algorithms for predictive maintenance of power system components to utilize historical data and real-time monitoring to predict failures and schedule maintenance.

**PC6.** Discuss AI techniques for analyzing data from smart meters, providing insights into consumer behavior, enhancing billing accuracy and supporting dynamic pricing model.

*Use AI tools /algorithms in Control Systems and Automation*

To be competent, the user/individual on the job must be able to:

**PC7.** Discuss AI algorithms to develop adaptive control strategies that adjust system parameters in real-time based on changing conditions, improving system performance and stability.

**PC8.** Discuss machine learning techniques to enhance model Predictive Control, allowing for better prediction of future system behavior and optimal control actions in dynamic environments.

**PC9.** Understand AI-driven fault detection and isolation algorithms to develop fault-tolerant control systems, ensuring continued operation and performance in the presence of faults or disturbances.

**PC10.** Describe AI tools to automate industrial processes through intelligent control systems, optimizing production efficiency, reducing downtime and enhancing safety in manufacturing environments.

**PC11.** Understand AI techniques to design robust control systems that handle uncertainties and variations in system dynamics, ensuring reliable performance under different operating conditions.

**PC12.** Discuss data-driven approaches in control systems by utilizing AI algorithms to analyze historical data for improving control strategies and system designs based on performance feedback.

*Utilize AI tools /algorithms in Signal Processing and Communication Systems*

To be competent, the user/individual on the job must be able to:

**PC13.** Understand AI algorithms to develop advanced filtering techniques that effectively remove noise and interference from signals, improving the quality and clarity of communication systems.

**PC14.** Decribe machine learning models for automatic modulation classification, enabling the system to identify and adapt to different modulation schemes used in communication channels.

**PC15.** Discuss AI techniques for adaptive equalization in communication systems, allowing for real-time adjustments to counteract channel distortions and maintain signal integrity.

**PC16.** Understand AI-driven methods for speech recognition and audio processing, enhancing applications such as voice communication systems, noise cellation, and audio enhancement.

**PC17.** Discuss deep learning algorithms in image and video signal processing to improve compression, enhance resolution, and enable real-time analysis in applications like video conferencing and broadcasting.

**PC18.** Explain AI-based algorithms for cognitive radio networks that dynamically allocate spectrum resources, optimizing communication efficiency and reducing interference among users.

*Use AI tools /algorithms in Electronics and Embedded Systems*

To be competent, the user/individual on the job must be able to:

**PC19.** Explain AI algorithms in embedded systems to enable smart sensors capable of real-time data processing and decision-making, enhancing the functionality of applications such as environmental monitoring and healthcare devices.

**PC20.** Understand AI techniques in electronics design to optimize power consumption in embedded systems, enabling energy-efficient operations in battery-powered devices and IoT applications.

**PC21.** Discuss machine learning models to predict failures and maintenance needs in embedded systems, ensuring reliability and minimizing downtime in critical applications like industrial automation.

**PC22.** Describe AI tools for real-time data processing in embedded systems, allowing for immediate response and control in applications such as robotics, automotive systems, and home automation.

**PC23.** Discuss AI-driven algorithms to automate the configuration and tuning of embedded systems, improving performance while reducing the time and expertise required for manual setup.

**PC24.** Understand adaptive control algorithms for embedded systems that learn and adjust their operations based on environmental changes or user interactions, enhancing flexibility and user experience.

*Utilize AI tools /algorithms in Renewable Energy Systems*

To be competent, the user/individual on the job must be able to:

**PC25.** Discuss AI algorithms to forecast renewable energy generation such as solar and wind based on weather patterns and historical data, optimizing energy dispatch and storage strategies.

**PC26.** Understand AI tools to facilitate the integration of renewable energy sources into smart grids, enabling dynamic load balancing, improved reliability, and efficient distribution of generated energy.

**PC27.** Discuss machine learning models to optimize the management and operation of energy storage systems like batteries, ensuring efficient energy use and maximizing the lifespan of storage components.

**PC28.** Describe AI-driven strategies for demand response programs that adjust consumer energy usage in real-time, aligning with renewable energy supply and enhancing grid stability.

**PC29.** Understand AI techniques for predictive maintenance in renewable energy systems (e.g., wind turbines and solar panels), enabling early fault detection and reducing operational downtime.

**PC30.** Explain AI algorithms to optimize the performance of hybrid renewable energy systems (combining solar, wind, and storage), ensuring efficient energy production and consumption while minimizing costs.

*Use AI tools /algorithms in Robotics and Autonomous Systems*

To be competent, the user/individual on the job must be able to:

**PC31.** Understand AI algorithms for real-time path planning and obstacle avoidance in autonomous vehicles and robotic systems, enhancing their ability to navigate complex environments safely and efficiently.

**PC32.** Discuss computer vision techniques powered by AI to enable robots to perceive and interpret their surroundings, facilitating tasks such as object recognition, classification, and manipulation.

**PC33.** Describe AI to integrate data from multiple sensors (like LiDAR, cameras, and IMUs) in robotic systems, improving accuracy and reliability in environmental perception and decision- making.

**PC34.** Understand machine learning algorithms for adaptive control in robotics, allowing systems to learn and optimize their performance based on changing conditions and user interactions.

**PC35.** Describe AI tools to enhance human-robot interaction through natural language processing and gesture recognition, enabling more intuitive communication and collaboration between humans and robots.

**PC36.** Discuss AI-driven strategies for coordinating multiple robotic units in swarm robotics applications, optimizing task distribution and improving efficiency in collective operations.

*Utilize AI tools /algorithms for Electric Vehicles*

To be competent, the user/individual on the job must be able to:

**PC37.** Understand AI algorithms to optimize battery performance in electric vehicles by improving charge/discharge cycles, extending battery life and enhancing overall energy efficiency.

**PC38.** Describe machine learning models to predict failures or maintenance needs in critical EV components such as the motor, battery, and drive train, reducing downtime and operational costs.

**PC39.** Discuss AI tools to optimize energy consumption in real-time based on driving conditions, route planning, and user preferences, maximizing the driving range of electric vehicles.

**PC40.** Understand AI algorithms in the development of autonomous driving features for electric vehicles, enabling functionalities like lane-keeping, collision avoidance and automated parking.

**PC41.** Explain AI-driven solutions to optimize the placement, availability, and utilization of EV charging stations, enhancing accessibility and minimizing waiting times for users.

**PC42.** Discuss AI tools to improve regenerative braking efficiency by adapting the system to different driving styles and conditions, recovering more energy during deceleration.

*Advancement in AI for Electrical Engineering*

To be competent, the user/individual on the job must be able to:

**PC43.** Understand advanced AI algorithms to improve real-time monitoring, control, and optimization of smart grids, enabling more efficient power distribution and integration of renewable energy sources.

**PC44.** Discuss AI tools to predict and manage voltage and frequency fluctuations in power systems, enhancing grid stability and preventing blackouts.

**PC45.** Understand AI-driven solutions to optimize the integration of renewable energy sources like solar and wind into the electrical grid, managing variability and improving energy storage efficiency.

**PC46.** Describe AI-based adaptive systems that dynamically adjust energy consumption and distribution based on real-time data from electrical networks and smart devices, improving overall energy efficiency.

**PC47.** Discuss AI tools to analyze large datasets from electrical grids to predict potential faults or cyber threats, improving grid resilience and safeguarding infrastructure from disruptions.

**PC48.** Understand AI algorithms to manage and optimize electric vehicle charging networks, ensuring efficient load balancing, reduced charging times, and enhanced user experience.

## Knowledge and Understanding (KU)

The individual on the job needs to know and understand:

**KU1.** AI algorithms enhance smart grids by improving real-time power distribution, load balancing, and fault detection, leading to more efficient and reliable power systems.

**KU2.** AI-based models for accurate load forecasting, which helps utilities predict electricity demand and optimize power generation and distribution.

**KU3.** AI applications in predictive maintenance of electrical equipment, such as transformers and motors, to detect faults early and minimize downtime.

**KU4.** AI techniques used to manage and integrate renewable energy sources like solar and wind into the grid, balancing intermittent power supply with demand.

**KU5.** AI-driven energy management systems (EMS) optimize consumption patterns in industrial, commercial, and residential settings, reducing overall energy usage.

**KU6.** AI algorithms that automate fault detection and diagnostics in electrical circuits, improving system reliability and reducing manual intervention.

**KU7.** Role of AI in maintaining voltage and frequency stability in power systems by monitoring and dynamically adjusting system parameters.

**KU8.** AI tools are used in designing and optimizing power electronic devices, such as converters and inverters, improving their efficiency and performance.

**KU9.** AI enhances cybersecurity in electrical grids by detecting and mitigating cyber threats, ensuring the integrity of critical infrastructure.

**KU10.** AI applications in optimizing electric vehicle (EV) charging networks, including smart charging, load management and integration with renewable energy sources.

## Generic Skills (GS)

User/individual on the job needs to know how to:

**GS1.** Listen and communicate effectively and accurately.

**GS2.** Apply problem-solving approaches for different situations.

**GS3.** Work effectively in a team.

**GS4.** Employ proper time management.

**GS5.** Plan and organize work.

**GS6.** Maintain hygiene and sanitation.

**GS7.** Analytical Skills.

## Assessment Criteria

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| *Utilize AI tools /algorithms in Power Systems and Smart Grids* | **5** | **7** | **-** | **2** |
| **PC1.** Understand AI algorithms for accurate real-time load forecasting in power systems, enabling better demand response and resource allocation to enhance grid reliability and efficiency. | - | - | - | - |
| **PC2.** Discuss AI-driven techniques for automated fault detection and diagnosis in power systems, improving the speed and accuracy of identifying issues and minimizing downtime. | - | - | - | - |
| **PC3.** Describe machine learning models to optimize the operation of smart grids, enhancing energy distribution, reducing losses, and integrating renewable energy sources effectively. | - | - | - | - |
| **PC4.** Explore AI tools in energy management systems to analyze consumption patterns, optimize energy usage and implement demand-side management strategies for residential and industrial application. | - | - | - | - |
| **PC5.** Understand AI algorithms for predictive maintenance of power system components to utilize historical data and real-time monitoring to predict failures and schedule maintenance. | - | - | - | - |
| **PC6.** Discuss AI techniques for analyzing data from smart meters, providing insights into consumer behavior, enhancing billing accuracy and supporting dynamic pricing model. | - | - | - | - |
| *Use AI tools /algorithms in Control Systems and Automation* | **5** | **7** | **-** | **2** |
| **PC7.** Discuss AI algorithms to develop adaptive control strategies that adjust system parameters in real-time based on changing conditions, improving system performance and stability. | - | - | - | - |
| **PC8.** Discuss machine learning techniques to enhance model Predictive Control, allowing for better prediction of future system behavior and optimal control actions in dynamic environments. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC9.** Understand AI-driven fault detection and isolation algorithms to develop fault-tolerant control systems, ensuring continued operation and performance in the presence of faults or disturbances. | - | - | - | - |
| **PC10.** Describe AI tools to automate industrial processes through intelligent control systems, optimizing production efficiency, reducing downtime and enhancing safety in manufacturing environments. | - | - | - | - |
| **PC11.** Understand AI techniques to design robust control systems that handle uncertainties and variations in system dynamics, ensuring reliable performance under different operating conditions. | - | - | - | - |
| **PC12.** Discuss data-driven approaches in control systems by utilizing AI algorithms to analyze historical data for improving control strategies and system designs based on performance feedback. | - | - | - | - |
| *Utilize AI tools /algorithms in Signal Processing and Communication Systems* | **5** | **6** | **-** | **1** |
| **PC13.** Understand AI algorithms to develop advanced filtering techniques that effectively remove noise and interference from signals, improving the quality and clarity of communication systems. | - | - | - | - |
| **PC14.** Decribe machine learning models for automatic modulation classification, enabling the system to identify and adapt to different modulation schemes used in communication channels. | - | - | - | - |
| **PC15.** Discuss AI techniques for adaptive equalization in communication systems, allowing for real- time adjustments to counteract channel distortions and maintain signal integrity. | - | - | - | - |
| **PC16.** Understand AI-driven methods for speech recognition and audio processing, enhancing applications such as voice communication systems, noise cellation, and audio enhancement. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC17.** Discuss deep learning algorithms in image and video signal processing to improve compression, enhance resolution, and enable real-time analysis in applications like video conferencing and broadcasting. | - | - | - | - |
| **PC18.** Explain AI-based algorithms for cognitive radio networks that dynamically allocate spectrum resources, optimizing communication efficiency and reducing interference among users. | - | - | - | - |
| *Use AI tools /algorithms in Electronics and Embedded Systems* | **5** | **6** | **-** | **1** |
| **PC19.** Explain AI algorithms in embedded systems to enable smart sensors capable of real-time data processing and decision-making, enhancing the functionality of applications such as environmental monitoring and healthcare devices. | - | - | - | - |
| **PC20.** Understand AI techniques in electronics design to optimize power consumption in embedded systems, enabling energy-efficient operations in battery-powered devices and IoT applications. | - | - | - | - |
| **PC21.** Discuss machine learning models to predict failures and maintenance needs in embedded systems, ensuring reliability and minimizing downtime in critical applications like industrial automation. | - | - | - | - |
| **PC22.** Describe AI tools for real-time data processing in embedded systems, allowing for immediate response and control in applications such as robotics, automotive systems, and home automation. | - | - | - | - |
| **PC23.** Discuss AI-driven algorithms to automate the configuration and tuning of embedded systems, improving performance while reducing the time and expertise required for manual setup. | - | - | - | - |
| **PC24.** Understand adaptive control algorithms for embedded systems that learn and adjust their operations based on environmental changes or user interactions, enhancing flexibility and user experience. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| *Utilize AI tools /algorithms in Renewable Energy Systems* | **5** | **6** | **-** | **1** |
| **PC25.** Discuss AI algorithms to forecast renewable energy generation such as solar and wind based on weather patterns and historical data, optimizing energy dispatch and storage strategies. | - | - | - | - |
| **PC26.** Understand AI tools to facilitate the integration of renewable energy sources into smart grids, enabling dynamic load balancing, improved reliability, and efficient distribution of generated energy. | - | - | - | - |
| **PC27.** Discuss machine learning models to optimize the management and operation of energy storage systems like batteries, ensuring efficient energy use and maximizing the lifespan of storage components. | - | - | - | - |
| **PC28.** Describe AI-driven strategies for demand response programs that adjust consumer energy usage in real-time, aligning with renewable energy supply and enhancing grid stability. | - | - | - | - |
| **PC29.** Understand AI techniques for predictive maintenance in renewable energy systems (e.g., wind turbines and solar panels), enabling early fault detection and reducing operational downtime. | - | - | - | - |
| **PC30.** Explain AI algorithms to optimize the performance of hybrid renewable energy systems (combining solar, wind, and storage), ensuring efficient energy production and consumption while minimizing costs. | - | - | - | - |
| *Use AI tools /algorithms in Robotics and Autonomous Systems* | **5** | **6** | **-** | **1** |
| **PC31.** Understand AI algorithms for real-time path planning and obstacle avoidance in autonomous vehicles and robotic systems, enhancing their ability to navigate complex environments safely and efficiently. | - | - | - | - |
| **PC32.** Discuss computer vision techniques powered by AI to enable robots to perceive and interpret their surroundings, facilitating tasks such as object recognition, classification, and manipulation. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC33.** Describe AI to integrate data from multiple sensors (like LiDAR, cameras, and IMUs) in robotic systems, improving accuracy and reliability in environmental perception and decision- making. | - | - | - | - |
| **PC34.** Understand machine learning algorithms for adaptive control in robotics, allowing systems to learn and optimize their performance based on changing conditions and user interactions. | - | - | - | - |
| **PC35.** Describe AI tools to enhance human-robot interaction through natural language processing and gesture recognition, enabling more intuitive communication and collaboration between humans and robots. | - | - | - | - |
| **PC36.** Discuss AI-driven strategies for coordinating multiple robotic units in swarm robotics applications, optimizing task distribution and improving efficiency in collective operations. | - | - | - | - |
| *Utilize AI tools /algorithms for Electric Vehicles* | **5** | **6** | **-** | **1** |
| **PC37.** Understand AI algorithms to optimize battery performance in electric vehicles by improving charge/discharge cycles, extending battery life and enhancing overall energy efficiency. | - | - | - | - |
| **PC38.** Describe machine learning models to predict failures or maintenance needs in critical EV components such as the motor, battery, and drive train, reducing downtime and operational costs. | - | - | - | - |
| **PC39.** Discuss AI tools to optimize energy consumption in real-time based on driving conditions, route planning, and user preferences, maximizing the driving range of electric vehicles. | - | - | - | - |
| **PC40.** Understand AI algorithms in the development of autonomous driving features for electric vehicles, enabling functionalities like lane-keeping, collision avoidance and automated parking. | - | - | - | - |
| **PC41.** Explain AI-driven solutions to optimize the placement, availability, and utilization of EV charging stations, enhancing accessibility and minimizing waiting times for users. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC42.** Discuss AI tools to improve regenerative braking efficiency by adapting the system to different driving styles and conditions, recovering more energy during deceleration. | - | - | - | - |
| *Advancement in AI for Electrical Engineering* | **5** | **6** | **-** | **1** |
| **PC43.** Understand advanced AI algorithms to improve real-time monitoring, control, and optimization of smart grids, enabling more efficient power distribution and integration of renewable energy sources. | - | - | - | - |
| **PC44.** Discuss AI tools to predict and manage voltage and frequency fluctuations in power systems, enhancing grid stability and preventing blackouts. | - | - | - | - |
| **PC45.** Understand AI-driven solutions to optimize the integration of renewable energy sources like solar and wind into the electrical grid, managing variability and improving energy storage efficiency. | - | - | - | - |
| **PC46.** Describe AI-based adaptive systems that dynamically adjust energy consumption and distribution based on real-time data from electrical networks and smart devices, improving overall energy efficiency. | - | - | - | - |
| **PC47.** Discuss AI tools to analyze large datasets from electrical grids to predict potential faults or cyber threats, improving grid resilience and safeguarding infrastructure from disruptions. | - | - | - | - |
| **PC48.** Understand AI algorithms to manage and optimize electric vehicle charging networks, ensuring efficient load balancing, reduced charging times, and enhanced user experience. | - | - | - | - |
| **NOS Total** | **40** | **50** | **-** | **10** |

## National Occupational Standards (NOS) Parameters

| | |
|---|---|
| **NOS Code** | ICE/ITS/N0206 |
| **NOS Name** | Applications of AI tools/algorithms in Electrical Engineering |
| **Sector** | Information Technology Sector |
| **Sub-Sector** | |
| **Occupation** | Artificial Intelligence |
| **NSQF Level** | 5 |
| **Credits** | 10 |
| **Version** | 1.0 |
| **Last Reviewed Date** | 17/12/2024 |
| **Next Review Date** | 17/12/2027 |
| **NSQC Clearance Date** | 17/12/2024 |

# ICE/ITS/N0207: Applications of AI tools/algorithms in Mechanical Engineering

## Description

This module addresses the applications of AI tools and algorithms in mechanical engineering, emphasizing the optimization of design and manufacturing processes, the enhancement of system performance, and the use of predictive analytics to facilitate better decision-making.

## Scope

The scope covers the following :

- Integration of AI in product design and development.
- Optimization of manufacturing processes using AI algorithms.
- Implementation of predictive maintenance strategies for machinery.
- Application of AI in control systems and automation.
- Development of smart machinery for improved energy efficiency.
- Enhancements in sustainability practices within mechanical engineering applications.

## Elements and Performance Criteria

*Utilize AI tools /algorithms in Product Development*

To be competent, the user/individual on the job must be able to:

**PC1.** Understand AI algorithms to enhance product design processes by optimizing mechanical components for efficiency, performance and cost-effectiveness based on multiple design parameters and constraints.

**PC2.** Discuss AI tools to generate innovative design solutions automatically, exploring a wide range of design options for mechanical systems that humans might not easily envision, thus fostering innovation in product development.

**PC3.** Describe AI to predict product performance by running simulations, such as stress tests and fatigue analysis, allowing for early identification of design flaws and reducing the need for physical prototypes.

**PC4.** ExplainAI algorithms to analyze material properties and performance, helping engineers select the most appropriate materials for product development based on desired characteristics like durability, weight, and cost.

**PC5.** Explore AI tools to streamline the prototyping process by integrating AI-driven 3D printing and manufacturing simulations, reducing lead time and costs associated with traditional prototyping.

**PC6.** Understand AI for analyzing data from product testing to improve design iterations, identifying areas for refinement and predicting potential failure modes to enhance product reliability and lifecycle performance.

*Use AI tools /algorithms in Manufacturing and Production Systems*

To be competent, the user/individual on the job must be able to:

**PC7.** Discuss AI algorithms to predict when machinery or equipment is likely to fail, enabling proactive maintenance scheduling that minimizes downtime and extends equipment lifespan.

**PC8.** Understand AI tools to optimize manufacturing processes by analyzing production data in real- time, reducing inefficiencies, improving throughput, and minimizing waste in production systems.

**PC9.** Describe AI with robotics in manufacturing to automate complex tasks, enhance precision, and adapt to changes in production needs, leading to increased efficiency and flexibility in production lines.

**PC10.** Explain AI-driven visual inspection systems to automatically detect defects and ensure consistent quality in manufactured products, reducing human error and improving product reliability.

**PC11.** Explore AI tools for demand forecasting and inventory management to optimize the supply chain, ensuring timely delivery of raw materials and minimizing production delays.

**PC12.** Understand AI to create adaptive manufacturing systems that adjust parameters, such as temperature, speed, or pressure, autonomously in response to real-time feedback, ensuring optimal production conditions.

### *Utilize AI tools /algorithms in Predictive Maintenance and Reliability Engineering*

To be competent, the user/individual on the job must be able to:

**PC13.** Discuss AI tools to continuously monitor equipment conditions using sensors and data analytics, identifying abnormal patterns in vibration, temperature, and other key parameters to predict potential failures.

**PC14.** Understand AI algorithms to develop predictive models that forecast when mechanical components are likely to fail based on historical data, usage patterns, and operational conditions, allowing for timely maintenance.

**PC15.** Explain machine learning techniques to analyze large datasets from equipment operations, enabling data-driven insights to improve reliability, optimize maintenance schedules, and reduce unexpected breakdowns.

**PC16.** Understand AI-powered anomaly detection systems to automatically detect deviations from normal operational behavior in machinery, signaling early signs of wear, degradation, or potential failure.

**PC17.** Explore AI tools to optimize maintenance planning by predicting the most effective times for repairs or replacements, balancing cost and minimizing downtime, and extending the operational life of assets.

**PC18.** Explore AI algorithms to perform automated root cause analysis, identifying the underlying causes of equipment failures more quickly and accurately, improving future reliability and performance.

### *Use AI tools /algorithms in Control Systems and Automation*

To be competent, the user/individual on the job must be able to:

**PC19.** Understand AI algorithms to create adaptive control systems that autonomously adjust operational parameters in real-time based on changes in environmental conditions, load, or process requirements, optimizing performance and efficiency.

**PC20.** Explain AI-based predictive models to anticipate future system behavior and adjust control actions accordingly, improving response times and minimizing errors in automated processes.

**PC21.** Explore AI tools to enable control systems that self-optimize through continuous learning from operational data, improving accuracy and reducing manual interventions in automation processes.

**PC22.** Discuss AI algorithms to detect faults and anomalies in control systems, enabling real-time diagnosis and automatic corrective actions that prevent system failure or downtime in automated processes.

**PC23.** Describe AI into automation systems to improve robustness and flexibility, allowing machines to handle complex tasks with minimal human oversight, adapt to changing production needs, and reduce operational inefficiencies.

**PC24.** Explore AI tools to analyze control system data and optimize energy consumption by adjusting control parameters to ensure energy-efficient operation without compromising performance.

*Utilize AI tools /algorithms in Fluid Mechanics and Thermal Systems*

To be competent, the user/individual on the job must be able to:

**PC25.** Discuss AI algorithms to predict complex flow patterns in fluid systems, enhancing the design and optimization of pipelines, HVAC systems and fluid transport in various engineering applications.

**PC26.** Describe AI tools to optimize the performance of thermal systems, such as heat exchangers or refrigeration units, by analyzing system data to improve heat transfer efficiency and energy consumption.

**PC27.** Understand AI with CFD simulations to reduce computational time and cost, while increasing the accuracy of simulations for fluid flow, pressure distribution and thermal management.

**PC28.** Discuss AI algorithms to continuously monitor fluid and thermal systems in real time, detecting anomalies or inefficiencies in the system and providing predictive maintenance insights.

**PC29.** Discuss AI tools to analyze operational data in thermal systems and adjust control parameters to improve energy efficiency, reducing operational costs and environmental impact.

**PC30.** Explain AI-driven optimization techniques to improve the design of pumps, turbines, compressors, and other fluid mechanics components, ensuring better performance under various conditions.

*Use AI tools /algorithms in Energy Systems and Sustainability*

To be competent, the user/individual on the job must be able to:

**PC31.** Discuss AI algorithms to analyze energy usage patterns in mechanical systems, optimizing operational processes to reduce overall energy consumption and increase energy efficiency.

**PC32.** Understand AI tools to improve the integration of renewable energy sources (solar, wind, etc.) into existing energy systems by predicting energy availability and optimizing energy storage and distribution.

**PC33.** Explain AI for real-time monitoring and optimization of smart grids, ensuring efficient energy distribution, load balancing and minimizing energy losses in large-scale energy systems.

**PC34.** Describe AI-driven predictive maintenance techniques to monitor the health of energy systems, detecting potential failures early and reducing downtime, which enhances system reliability and sustainability.

**PC35.** Explore AI tools to identify inefficiencies and recommend improvements in mechanical processes, reducing waste and emissions, and enhancing the overall sustainability of energy systems.

**PC36.** Understand AI to optimize energy storage systems, such as batteries and thermal storage units, improving charge/discharge cycles, extending system lifespan, and ensuring energy availability when demand is high.

*Utilize AI tools /algorithms in Materials Science and Additive Manufacturing*

To be competent, the user/individual on the job must be able to:

**PC37.** Discuss AI algorithms to predict the properties of new materials based on their composition and processing conditions, enabling the design of advanced materials with tailored characteristics for specific applications.

**PC38.** Understand AI tools to optimize parameters in additive manufacturing processes (such as 3D printing), enhancing print quality, reducing defects, and minimizing material waste.

**PC39.** Describe machine learning techniques to analyze large datasets from experimental and computational studies, accelerating the discovery of new materials with desirable properties for mechanical applications.

**PC40.** Explain AI for real-time monitoring and control of additive manufacturing processes, ensuring consistent product quality and enabling immediate adjustments to parameters to reduce variability.

**PC41.** Discuss AI algorithms to conduct life cycle assessments of materials and manufacturing processes, identifying opportunities for reducing environmental impact and promoting sustainable practices in materials science.

**PC42.** Understand AI techniques to predict potential failures in materials based on stress and strain data, enabling proactive maintenance strategies and improving the reliability and safety of mechanical components.

*Advancement in AI for Mechanical Engineering*

To be competent, the user/individual on the job must be able to:

**PC43.** Explore advanced machine learning algorithms to analyze historical design data, enabling the identification of design patterns that lead to innovative product developments in mechanical engineering.

**PC44.** Understand AI technologies to improve robotic systems in manufacturing and assembly lines, enhancing their capabilities in adaptive learning, object recognition, and task execution.

**PC45.** Discuss AI-driven data analytics to optimize manufacturing processes, allowing for real-time adjustments based on performance data, leading to increased productivity and reduced operational costs.

**PC46.** Explain research and develop AI-integrated smart materials that change properties in response to environmental conditions, enabling the creation of adaptive systems in mechanical applications such as aerospace and automotive engineering.

**PC47.** Explore AI technologies in simulation tools to create virtual prototypes that predict mechanical behavior under various scenarios.

## Knowledge and Understanding (KU)

The individual on the job needs to know and understand:

**KU1.** AI algorithms analyze equipment data to predict failures, enabling proactive maintenance and reducing downtime in mechanical systems.

**KU2.** AI techniques that assist in optimizing design parameters, leading to more efficient and innovative product designs in mechanical engineering.

**KU3.** AI applications in robotics, including machine learning and computer vision, to enhance the capabilities of automated systems in manufacturing and assembly processes.
**KU4.** AI is employed to simulate and analyze fluid flow and thermal behavior in various mechanical systems, improving efficiency and performance.
**KU5.** Role of AI in optimizing energy consumption and performance in mechanical systems, such as HVAC and renewable energy systems.
**KU6.** AI-enhanced FEA tools that improve the accuracy of simulations for stress, strain, and thermal analysis in mechanical components.
**KU7.** AI applications in real-time monitoring and control of manufacturing processes, enabling increased efficiency, quality, and reduced waste.
**KU8.** AI optimizes designs specifically for additive manufacturing processes.
**KU9.** Intersection of AI and IoT, enabling smart mechanical systems.

## Generic Skills (GS)

User/individual on the job needs to know how to:

**GS1.** Listen and communicate effectively and accurately.
**GS2.** Apply problem-solving approaches for different situations.
**GS3.** Work effectively in a team.
**GS4.** Employ proper time management
**GS5.** Plan and organize work
**GS6.** Maintain hygiene and sanitation.
**GS7.** Analytical skills.

## Assessment Criteria

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| *Utilize AI tools /algorithms in Product Development* | **5** | **6** | **-** | **2** |
| **PC1.** Understand AI algorithms to enhance product design processes by optimizing mechanical components for efficiency, performance and cost-effectiveness based on multiple design parameters and constraints. | - | - | - | - |
| **PC2.** Discuss AI tools to generate innovative design solutions automatically, exploring a wide range of design options for mechanical systems that humans might not easily envision, thus fostering innovation in product development. | - | - | - | - |
| **PC3.** Describe AI to predict product performance by running simulations, such as stress tests and fatigue analysis, allowing for early identification of design flaws and reducing the need for physical prototypes. | - | - | - | - |
| **PC4.** ExplainAI algorithms to analyze material properties and performance, helping engineers select the most appropriate materials for product development based on desired characteristics like durability, weight, and cost. | - | - | - | - |
| **PC5.** Explore AI tools to streamline the prototyping process by integrating AI-driven 3D printing and manufacturing simulations, reducing lead time and costs associated with traditional prototyping. | - | - | - | - |
| **PC6.** Understand AI for analyzing data from product testing to improve design iterations, identifying areas for refinement and predicting potential failure modes to enhance product reliability and lifecycle performance. | - | - | - | - |
| *Use AI tools /algorithms in Manufacturing and Production Systems* | **5** | **6** | **-** | **2** |
| **PC7.** Discuss AI algorithms to predict when machinery or equipment is likely to fail, enabling proactive maintenance scheduling that minimizes downtime and extends equipment lifespan. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC8.** Understand AI tools to optimize manufacturing processes by analyzing production data in real- time, reducing inefficiencies, improving throughput, and minimizing waste in production systems. | - | - | - | - |
| **PC9.** Describe AI with robotics in manufacturing to automate complex tasks, enhance precision, and adapt to changes in production needs, leading to increased efficiency and flexibility in production lines. | - | - | - | - |
| **PC10.** Explain AI-driven visual inspection systems to automatically detect defects and ensure consistent quality in manufactured products, reducing human error and improving product reliability. | - | - | - | - |
| **PC11.** Explore AI tools for demand forecasting and inventory management to optimize the supply chain, ensuring timely delivery of raw materials and minimizing production delays. | - | - | - | - |
| **PC12.** Understand AI to create adaptive manufacturing systems that adjust parameters, such as temperature, speed, or pressure, autonomously in response to real-time feedback, ensuring optimal production conditions. | - | - | - | - |
| *Utilize AI tools /algorithms in Predictive Maintenance and Reliability Engineering* | **5** | **6** | **-** | **1** |
| **PC13.** Discuss AI tools to continuously monitor equipment conditions using sensors and data analytics, identifying abnormal patterns in vibration, temperature, and other key parameters to predict potential failures. | - | - | - | - |
| **PC14.** Understand AI algorithms to develop predictive models that forecast when mechanical components are likely to fail based on historical data, usage patterns, and operational conditions, allowing for timely maintenance. | - | - | - | - |
| **PC15.** Explain machine learning techniques to analyze large datasets from equipment operations, enabling data-driven insights to improve reliability, optimize maintenance schedules, and reduce unexpected breakdowns. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC16.** Understand AI-powered anomaly detection systems to automatically detect deviations from normal operational behavior in machinery, signaling early signs of wear, degradation, or potential failure. | - | - | - | - |
| **PC17.** Explore AI tools to optimize maintenance planning by predicting the most effective times for repairs or replacements, balancing cost and minimizing downtime, and extending the operational life of assets. | - | - | - | - |
| **PC18.** Explore AI algorithms to perform automated root cause analysis, identifying the underlying causes of equipment failures more quickly and accurately, improving future reliability and performance. | - | - | - | - |
| *Use AI tools /algorithms in Control Systems and Automation* | **5** | **7** | **-** | **1** |
| **PC19.** Understand AI algorithms to create adaptive control systems that autonomously adjust operational parameters in real-time based on changes in environmental conditions, load, or process requirements, optimizing performance and efficiency. | - | - | - | - |
| **PC20.** Explain AI-based predictive models to anticipate future system behavior and adjust control actions accordingly, improving response times and minimizing errors in automated processes. | - | - | - | - |
| **PC21.** Explore AI tools to enable control systems that self-optimize through continuous learning from operational data, improving accuracy and reducing manual interventions in automation processes. | - | - | - | - |
| **PC22.** Discuss AI algorithms to detect faults and anomalies in control systems, enabling real-time diagnosis and automatic corrective actions that prevent system failure or downtime in automated processes. | - | - | - | - |
| **PC23.** Describe AI into automation systems to improve robustness and flexibility, allowing machines to handle complex tasks with minimal human oversight, adapt to changing production needs, and reduce operational inefficiencies. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC24.** Explore AI tools to analyze control system data and optimize energy consumption by adjusting control parameters to ensure energy-efficient operation without compromising performance. | - | - | - | - |
| *Utilize AI tools /algorithms in Fluid Mechanics and Thermal Systems* | **5** | **7** | **-** | **1** |
| **PC25.** Discuss AI algorithms to predict complex flow patterns in fluid systems, enhancing the design and optimization of pipelines, HVAC systems and fluid transport in various engineering applications. | - | - | - | - |
| **PC26.** Describe AI tools to optimize the performance of thermal systems, such as heat exchangers or refrigeration units, by analyzing system data to improve heat transfer efficiency and energy consumption. | - | - | - | - |
| **PC27.** Understand AI with CFD simulations to reduce computational time and cost, while increasing the accuracy of simulations for fluid flow, pressure distribution and thermal management. | - | - | - | - |
| **PC28.** Discuss AI algorithms to continuously monitor fluid and thermal systems in real time, detecting anomalies or inefficiencies in the system and providing predictive maintenance insights. | - | - | - | - |
| **PC29.** Discuss AI tools to analyze operational data in thermal systems and adjust control parameters to improve energy efficiency, reducing operational costs and environmental impact. | - | - | - | - |
| **PC30.** Explain AI-driven optimization techniques to improve the design of pumps, turbines, compressors, and other fluid mechanics components, ensuring better performance under various conditions. | - | - | - | - |
| *Use AI tools /algorithms in Energy Systems and Sustainability* | **5** | **6** | **-** | **1** |
| **PC31.** Discuss AI algorithms to analyze energy usage patterns in mechanical systems, optimizing operational processes to reduce overall energy consumption and increase energy efficiency. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC32.** Understand AI tools to improve the integration of renewable energy sources (solar, wind, etc.) into existing energy systems by predicting energy availability and optimizing energy storage and distribution. | - | - | - | - |
| **PC33.** Explain AI for real-time monitoring and optimization of smart grids, ensuring efficient energy distribution, load balancing and minimizing energy losses in large-scale energy systems. | - | - | - | - |
| **PC34.** Describe AI-driven predictive maintenance techniques to monitor the health of energy systems, detecting potential failures early and reducing downtime, which enhances system reliability and sustainability. | - | - | - | - |
| **PC35.** Explore AI tools to identify inefficiencies and recommend improvements in mechanical processes, reducing waste and emissions, and enhancing the overall sustainability of energy systems. | - | - | - | - |
| **PC36.** Understand AI to optimize energy storage systems, such as batteries and thermal storage units, improving charge/discharge cycles, extending system lifespan, and ensuring energy availability when demand is high. | - | - | - | - |
| *Utilize AI tools /algorithms in Materials Science and Additive Manufacturing* | **5** | **6** | **-** | **1** |
| **PC37.** Discuss AI algorithms to predict the properties of new materials based on their composition and processing conditions, enabling the design of advanced materials with tailored characteristics for specific applications. | - | - | - | - |
| **PC38.** Understand AI tools to optimize parameters in additive manufacturing processes (such as 3D printing), enhancing print quality, reducing defects, and minimizing material waste. | - | - | - | - |
| **PC39.** Describe machine learning techniques to analyze large datasets from experimental and computational studies, accelerating the discovery of new materials with desirable properties for mechanical applications. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC40.** Explain AI for real-time monitoring and control of additive manufacturing processes, ensuring consistent product quality and enabling immediate adjustments to parameters to reduce variability. | - | - | - | - |
| **PC41.** Discuss AI algorithms to conduct life cycle assessments of materials and manufacturing processes, identifying opportunities for reducing environmental impact and promoting sustainable practices in materials science. | - | - | - | - |
| **PC42.** Understand AI techniques to predict potential failures in materials based on stress and strain data, enabling proactive maintenance strategies and improving the reliability and safety of mechanical components. | - | - | - | - |
| *Advancement in AI for Mechanical Engineering* | **5** | **6** | **-** | **1** |
| **PC43.** Explore advanced machine learning algorithms to analyze historical design data, enabling the identification of design patterns that lead to innovative product developments in mechanical engineering. | - | - | - | - |
| **PC44.** Understand AI technologies to improve robotic systems in manufacturing and assembly lines, enhancing their capabilities in adaptive learning, object recognition, and task execution. | - | - | - | - |
| **PC45.** Discuss AI-driven data analytics to optimize manufacturing processes, allowing for real-time adjustments based on performance data, leading to increased productivity and reduced operational costs. | - | - | - | - |
| **PC46.** Explain research and develop AI-integrated smart materials that change properties in response to environmental conditions, enabling the creation of adaptive systems in mechanical applications such as aerospace and automotive engineering. | - | - | - | - |
| **PC47.** Explore AI technologies in simulation tools to create virtual prototypes that predict mechanical behavior under various scenarios. | - | - | - | - |
| **NOS Total** | **40** | **50** | **-** | **10** |

## National Occupational Standards (NOS) Parameters

| | |
|---|---|
| **NOS Code** | ICE/ITS/N0207 |
| **NOS Name** | Applications of AI tools/algorithms in Mechanical Engineering |
| **Sector** | Information Technology Sector |
| **Sub-Sector** | |
| **Occupation** | Artificial Intelligence |
| **NSQF Level** | 5 |
| **Credits** | 10 |
| **Version** | 1.0 |
| **Last Reviewed Date** | 17/12/2024 |
| **Next Review Date** | 17/12/2027 |
| **NSQC Clearance Date** | 17/12/2024 |

# ICE/ITS/N0208: Applications of AI tools/algorithms in Civil Engineering

## Description

This module provides learners with the tools and knowledge needed to effectively utilize AI in civil engineering, focusing on optimizing design and construction processes while enhancing decision-making and sustainability. Additionally, it covers the use of advanced analytics for infrastructure management, resource allocation, and predictive maintenance.

## Scope

The scope covers the following :

- Includes applications in structural analysis and design.
- Enhances construction management and project scheduling.
- Describe to geotechnical engineering for soil and foundation analysis.
- Involves transportation systems optimization and traffic management.
- Supports environmental engineering for sustainable practices.
- Aids in urban planning and the development of resilient infrastructure.

## Elements and Performance Criteria

*Utilize AI tools /algorithms in Structural Engineering*

To be competent, the user/individual on the job must be able to:

**PC1.** Discuss AI algorithms analyze data from sensors embedded in structures to monitor their health and detect anomalies.

**PC2.** Explain machine learning models to predict structures respond to various loads and environmental factors which aids in optimizing design and enhancing structural integrity.

**PC3.** Describe AI tools assist in optimizing structural designs by evaluating multiple parameters simultaneously.

**PC4.** Explore AI algorithms analyze the performance of different materials under various conditions, facilitating informed decisions about material selection and usage in structural applications.

**PC5.** Understand AI to assess risks associated with structural failures, including environmental impacts, and predicting potential vulnerabilities which enhances overall safety and resilience.

**PC6.** Discuss AI in robotic systems for automated construction tasks, such as precision placement of structural elements which improves efficiency and reduces human error in construction projects.

*Use AI tools /algorithms in Construction Management*

To be competent, the user/individual on the job must be able to:

**PC7.** Understand AI algorithms analyze project data to optimize scheduling, predicting task durations and resource allocation which improves project timelines and reduces delays.

**PC8.** Discuss AI tools automate cost estimation processes by analyzing historical data and current market trends, leading to more accurate budgets and effective financial management throughout the project lifecycle.

**PC9.** Understand AI-driven risk assessment models allows for the identification and evaluation of potential risks associated with construction projects, facilitating proactive mitigation strategies and enhancing project safety.

**PC10.** Explore AI optimize resource allocation by predicting demand for labor, materials, and equipment, ensuring that resources are efficiently used and reducing waste.

**PC11.** Describe AI-powered image recognition and analysis tools to monitor construction quality in real-time, enabling quicker detection of defects and adherence to project specifications.

*Utilize AI tools /algorithms in Geotechnical Engineering*

To be competent, the user/individual on the job must be able to:

**PC12.** Discuss AI algorithms analyze soil samples and historical data to predict soil properties, such as shear strength and compressibility, enhancing the accuracy of geotechnical assessments and reducing reliance on time-consuming laboratory tests.

**PC13.** Describe Machine learning models process large datasets from geological surveys and remote sensing technologies, enabling better site characterization and identification of subsurface conditions critical for design and construction.

**PC14.** Discuss AI tools simulate various environmental conditions and loading scenarios to assess slope stability, providing engineers with insights to mitigate risks of landslides and ensure safe construction practices.

**PC15.** Explain AI algorithms optimize foundation design by analyzing factors such as load distribution, soil properties, and site constraints, leading to more efficient and cost-effective foundation solutions.

**PC16.** Understand AI for monitoring and predicting the performance of geotechnical structures (like retaining walls and tunnels) helps in scheduling maintenance and preventing failures through early detection of potential issues.

**PC17.** Discuss AI tools facilitate comprehensive risk assessment models that analyze various factors affecting geotechnical projects, enabling engineers to develop effective risk mitigation strategies and ensure safer construction practices.

*Use AI tools /algorithms in Transportation Engineering*

To be competent, the user/individual on the job must be able to:

**PC18.** Understand AI algorithms analyze historical traffic data and real-time inputs to predict traffic patterns, enabling more effective traffic management and optimization of signal timings to reduce congestion.

**PC19.** Discuss AI in smart transportation systems facilitates real-time monitoring and control of transportation infrastructure, including adaptive traffic signals and dynamic message signs that adjust based on traffic conditions.

**PC20.** Describe AI tools provide optimal routing solutions for logistics and public transport systems by analyzing various factors, such as traffic conditions, road closures, and vehicle capacities, improving overall efficiency and reducing travel times.

**PC21.** Understand AI for predictive maintenance of transportation infrastructure, such as bridges and roads, enables early detection of structural issues through the analysis of sensor data, ensuring safety and longevity.

**PC22.** Explain AI algorithms automate traffic management processes by integrating data from various sources (cameras, sensors, and GPS) to enhance decision-making for managing incidents, accidents, and unusual traffic patterns.

**PC23.** Understand AI assist in evaluating the environmental impacts of transportation projects by analyzing data related to emissions, noise, and land use, helping engineers make informed decisions to promote sustainable transportation solutions.

*Utilize AI tools /algorithms in Environmental and Water Resources Engineering*

To be competent, the user/individual on the job must be able to:

**PC24.** Understand AI algorithms analyze data from sensors deployed in water bodies to continuously monitor water quality parameters (e.g., pH, turbidity, and contaminants), enabling timely interventions and ensuring compliance with environmental standards.

**PC25.** Explain machine learning models, engineers predict flood events based on historical data, rainfall patterns, and topographical features, allowing for better preparedness and resource allocation in flood-prone areas.

**PC26.** Explore AI tools to enhance the efficiency of water distribution networks by analyzing flow data, leak detection, and demand forecasting, leading to reduced water loss and improved service delivery in urban environments.

**PC27.** Discuss AI tools streamline the process of environmental impact assessments (EIAs) by analyzing vast amounts of data related to ecosystems, land use, and potential project impacts, helping to identify risks and propose mitigation strategies.

**PC28.** Understand AI algorithms be applied to predict maintenance needs for water treatment plants and distribution systems by analyzing equipment performance data and identifying patterns that indicate potential failures.

**PC29.** Describe AI facilitate the modeling of ecosystems and hydrological systems to evaluate the impact of various engineering projects, helping to balance development needs with environmental sustainability and resource conservation.

*Use AI tools /algorithms in Urban Planning and Smart Cities*

To be competent, the user/individual on the job must be able to:

**PC30.** Understand AI algorithms analyze real-time traffic data to optimize traffic flow, reduce congestion, and improve transportation efficiency in urban areas. This includes adaptive traffic signal control and predictive modeling of traffic patterns.

**PC31.** Describe AI tools assist in urban planning by predicting the demand for essential services (e.g., water, electricity, and waste management) based on population growth and usage patterns, leading to more efficient resource distribution and management.

**PC32.** Discuss AI analyze satellite imagery and weather data to identify urban heat islands and suggest interventions (e.g., increasing green spaces or reflective materials) that help cool cities and improve residents' quality of life.

**PC33.** Understand machine learning algorithms analyze historical data on crime, accidents, and emergencies to identify high-risk areas and optimize the placement of public safety resources, ensuring timely responses to incidents.

**PC34.** Understand AI be employed to monitor the health of urban infrastructure (e.g., bridges, roads, and buildings) using sensors and predictive analytics, enabling proactive maintenance and reducing the risk of failures.

**PC35.** Discuss AI tools facilitate community engagement by analyzing social media sentiment and public feedback, helping urban planners to understand community needs and preferences, ultimately leading to more inclusive and effective urban development strategies.

*Utilize AI tools /algorithms in Construction Automation*

To be competent, the user/individual on the job must be able to:

**PC36.** Understand AI-driven robots and drones perform tasks such as site surveying, material handling, and inspection.

**PC37.** Explain AI algorithms predict equipment failures and maintenance needs by analyzing historical data and sensor readings.

**PC38.** Describe AI analyze visual data from construction sites to identify defects in real-time, ensuring that construction quality meets standards.

**PC39.** Discuss AI tools assist in generating and optimizing design alternatives using algorithms that evaluate structural integrity, material usage, and cost.

**PC40.** Understand AI algorithms analyze site conditions and worker behaviors to predict and mitigate safety risks.

**PC41.** Discuss AI tools automate project scheduling and resource allocation by analyzing project timelines, available resources, and potential risks.

*Use AI tools /algorithms for Sustainable Civil Engineering*

To be competent, the user/individual on the job must be able to:

**PC42.** Understand AI algorithms analyze building designs and materials to optimize energy efficiency.

**PC43.** Discuss AI tools in selecting sustainable building materials by evaluating factors such as environmental impact, lifecycle analysis, and cost-effectiveness.

**PC44.** Decribe AI tools enhance waste management in construction projects by predicting waste generation patterns and optimizing recycling processes.

**PC45.** Understand AI algorithms model and manage water usage in construction projects, ensuring efficient water consumption and minimizing waste.

**PC46.** Explain AI tools analyze climate data to model the impact of environmental changes on infrastructure.

*Advancement in AI for Civil Engineering*

To be competent, the user/individual on the job must be able to:

**PC47.** Explain AI-driven generative design tools allow engineers to explore a wide range of design alternatives quickly.

**PC48.** Understand advanced machine learning algorithms analyze data from sensors embedded in structures to detect anomalies and predict maintenance needs.

**PC49.** Describe AI applications utilizing natural language processing (NLP) help civil engineers navigate complex regulatory documents and codes.

**PC50.** Explain AI algorithms analyze vast datasets related to environmental conditions, enabling more accurate predictions of a project’s ecological impact.

**PC51.** Understand advances in AI-powered robotics are transforming construction sites, enabling automated tasks such as bricklaying, welding, and excavation.

**PC52.** Explore AI technologies are essential for developing smart cities, where civil engineering projects are inter-connected through IoT devices.

## Knowledge and Understanding (KU)

The individual on the job needs to know and understand:

**KU1.** AI algorithms optimize structural designs by analyzing various parameters (e.g., materials, load conditions, and geometric configurations) to find the most efficient designs that meet safety and performance standards.

**KU2.** AI tools analyze data from sensors embedded in infrastructure (such as bridges and roads) to predict maintenance needs and potential failures, enhancing safety and extending the lifespan of civil structures.

**KU3.** AI algorithms improve project scheduling and resource allocation by analyzing historical project data, optimizing timelines, and predicting potential delays, thereby enhancing overall efficiency in construction management.

**KU4.** AI applications in traffic engineering analyze real-time traffic data to optimize traffic signal timings, predict congestion, and propose efficient routing solutions, improving urban mobility.

**KU5.** AI algorithms in geotechnical engineering by analyzing soil properties and predicting ground behavior under different loading conditions, which helps in designing foundations and earth-retaining structures.

**KU6.** AI tools analyze data related to environmental factors, helping engineers assess the potential impacts of construction projects on local ecosystems and water resources, leading to more sustainable designs.

**KU7.** AI tools to facilitate the development of smart cities by integrating various data sources (e.g., traffic, energy consumption, and weather patterns) to optimize urban planning and resource management.

**KU8.** Machine learning algorithms identify and evaluate risks associated with construction projects, allowing engineers to implement mitigation strategies proactively and ensure safety.

**KU9.** AI-powered image analysis process data from drones and satellite imagery to monitor construction progress, assess land use, and conduct site surveys, improving accuracy and efficiency in civil engineering practices.

## Generic Skills (GS)

User/individual on the job needs to know how to:

**GS1.** Listen and communicate effectively and accurately.
**GS2.** Apply problem-solving approaches for different situations.
**GS3.** Work effectively in a team.
**GS4.** Employ proper time management.
**GS5.** Plan and organize work.
**GS6.** Maintain hygiene and sanitation.
**GS7.** Analytical Skills.

## Assessment Criteria

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| *Utilize AI tools /algorithms in Structural Engineering* | **5** | **6** | **-** | **2** |
| **PC1.** Discuss AI algorithms analyze data from sensors embedded in structures to monitor their health and detect anomalies. | - | - | - | - |
| **PC2.** Explain machine learning models to predict structures respond to various loads and environmental factors which aids in optimizing design and enhancing structural integrity. | - | - | - | - |
| **PC3.** Describe AI tools assist in optimizing structural designs by evaluating multiple parameters simultaneously. | - | - | - | - |
| **PC4.** Explore AI algorithms analyze the performance of different materials under various conditions, facilitating informed decisions about material selection and usage in structural applications. | - | - | - | - |
| **PC5.** Understand AI to assess risks associated with structural failures, including environmental impacts, and predicting potential vulnerabilities which enhances overall safety and resilience. | - | - | - | - |
| **PC6.** Discuss AI in robotic systems for automated construction tasks, such as precision placement of structural elements which improves efficiency and reduces human error in construction projects. | - | - | - | - |
| *Use AI tools /algorithms in Construction Management* | **5** | **6** | **-** | **1** |
| **PC7.** Understand AI algorithms analyze project data to optimize scheduling, predicting task durations and resource allocation which improves project timelines and reduces delays. | - | - | - | - |
| **PC8.** Discuss AI tools automate cost estimation processes by analyzing historical data and current market trends, leading to more accurate budgets and effective financial management throughout the project lifecycle. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC9.** Understand AI-driven risk assessment models allows for the identification and evaluation of potential risks associated with construction projects, facilitating proactive mitigation strategies and enhancing project safety. | - | - | - | - |
| **PC10.** Explore AI optimize resource allocation by predicting demand for labor, materials, and equipment, ensuring that resources are efficiently used and reducing waste. | - | - | - | - |
| **PC11.** Describe AI-powered image recognition and analysis tools to monitor construction quality in real-time, enabling quicker detection of defects and adherence to project specifications. | - | - | - | - |
| *Utilize AI tools /algorithms in Geotechnical Engineering* | **5** | **6** | **-** | **1** |
| **PC12.** Discuss AI algorithms analyze soil samples and historical data to predict soil properties, such as shear strength and compressibility, enhancing the accuracy of geotechnical assessments and reducing reliance on time-consuming laboratory tests. | - | - | - | - |
| **PC13.** Describe Machine learning models process large datasets from geological surveys and remote sensing technologies, enabling better site characterization and identification of subsurface conditions critical for design and construction. | - | - | - | - |
| **PC14.** Discuss AI tools simulate various environmental conditions and loading scenarios to assess slope stability, providing engineers with insights to mitigate risks of landslides and ensure safe construction practices. | - | - | - | - |
| **PC15.** Explain AI algorithms optimize foundation design by analyzing factors such as load distribution, soil properties, and site constraints, leading to more efficient and cost-effective foundation solutions. | - | - | - | - |
| **PC16.** Understand AI for monitoring and predicting the performance of geotechnical structures (like retaining walls and tunnels) helps in scheduling maintenance and preventing failures through early detection of potential issues. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC17.** Discuss AI tools facilitate comprehensive risk assessment models that analyze various factors affecting geotechnical projects, enabling engineers to develop effective risk mitigation strategies and ensure safer construction practices. | - | - | - | - |
| *Use AI tools /algorithms in Transportation Engineering* | **5** | **6** | **-** | **1** |
| **PC18.** Understand AI algorithms analyze historical traffic data and real-time inputs to predict traffic patterns, enabling more effective traffic management and optimization of signal timings to reduce congestion. | - | - | - | - |
| **PC19.** Discuss AI in smart transportation systems facilitates real-time monitoring and control of transportation infrastructure, including adaptive traffic signals and dynamic message signs that adjust based on traffic conditions. | - | - | - | - |
| **PC20.** Describe AI tools provide optimal routing solutions for logistics and public transport systems by analyzing various factors, such as traffic conditions, road closures, and vehicle capacities, improving overall efficiency and reducing travel times. | - | - | - | - |
| **PC21.** Understand AI for predictive maintenance of transportation infrastructure, such as bridges and roads, enables early detection of structural issues through the analysis of sensor data, ensuring safety and longevity. | - | - | - | - |
| **PC22.** Explain AI algorithms automate traffic management processes by integrating data from various sources (cameras, sensors, and GPS) to enhance decision-making for managing incidents, accidents, and unusual traffic patterns. | - | - | - | - |
| **PC23.** Understand AI assist in evaluating the environmental impacts of transportation projects by analyzing data related to emissions, noise, and land use, helping engineers make informed decisions to promote sustainable transportation solutions. | - | - | - | - |
| *Utilize AI tools /algorithms in Environmental and Water Resources Engineering* | **4** | **6** | **-** | **1** |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC24.** Understand AI algorithms analyze data from sensors deployed in water bodies to continuously monitor water quality parameters (e.g., pH, turbidity, and contaminants), enabling timely interventions and ensuring compliance with environmental standards. | - | - | - | - |
| **PC25.** Explain machine learning models, engineers predict flood events based on historical data, rainfall patterns, and topographical features, allowing for better preparedness and resource allocation in flood-prone areas. | - | - | - | - |
| **PC26.** Explore AI tools to enhance the efficiency of water distribution networks by analyzing flow data, leak detection, and demand forecasting, leading to reduced water loss and improved service delivery in urban environments. | - | - | - | - |
| **PC27.** Discuss AI tools streamline the process of environmental impact assessments (EIAs) by analyzing vast amounts of data related to ecosystems, land use, and potential project impacts, helping to identify risks and propose mitigation strategies. | - | - | - | - |
| **PC28.** Understand AI algorithms be applied to predict maintenance needs for water treatment plants and distribution systems by analyzing equipment performance data and identifying patterns that indicate potential failures. | - | - | - | - |
| **PC29.** Describe AI facilitate the modeling of ecosystems and hydrological systems to evaluate the impact of various engineering projects, helping to balance development needs with environmental sustainability and resource conservation. | - | - | - | - |
| *Use AI tools /algorithms in Urban Planning and Smart Cities* | **4** | **5** | **-** | **1** |
| **PC30.** Understand AI algorithms analyze real-time traffic data to optimize traffic flow, reduce congestion, and improve transportation efficiency in urban areas. This includes adaptive traffic signal control and predictive modeling of traffic patterns. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC31.** Describe AI tools assist in urban planning by predicting the demand for essential services (e.g., water, electricity, and waste management) based on population growth and usage patterns, leading to more efficient resource distribution and management. | - | - | - | - |
| **PC32.** Discuss AI analyze satellite imagery and weather data to identify urban heat islands and suggest interventions (e.g., increasing green spaces or reflective materials) that help cool cities and improve residents' quality of life. | - | - | - | - |
| **PC33.** Understand machine learning algorithms analyze historical data on crime, accidents, and emergencies to identify high-risk areas and optimize the placement of public safety resources, ensuring timely responses to incidents. | - | - | - | - |
| **PC34.** Understand AI be employed to monitor the health of urban infrastructure (e.g., bridges, roads, and buildings) using sensors and predictive analytics, enabling proactive maintenance and reducing the risk of failures. | - | - | - | - |
| **PC35.** Discuss AI tools facilitate community engagement by analyzing social media sentiment and public feedback, helping urban planners to understand community needs and preferences, ultimately leading to more inclusive and effective urban development strategies. | - | - | - | - |
| *Utilize AI tools /algorithms in Construction Automation* | **4** | **5** | **-** | **1** |
| **PC36.** Understand AI-driven robots and drones perform tasks such as site surveying, material handling, and inspection. | - | - | - | - |
| **PC37.** Explain AI algorithms predict equipment failures and maintenance needs by analyzing historical data and sensor readings. | - | - | - | - |
| **PC38.** Describe AI analyze visual data from construction sites to identify defects in real-time, ensuring that construction quality meets standards. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC39.** Discuss AI tools assist in generating and optimizing design alternatives using algorithms that evaluate structural integrity, material usage, and cost. | - | - | - | - |
| **PC40.** Understand AI algorithms analyze site conditions and worker behaviors to predict and mitigate safety risks. | - | - | - | - |
| **PC41.** Discuss AI tools automate project scheduling and resource allocation by analyzing project timelines, available resources, and potential risks. | - | - | - | - |
| *Use AI tools /algorithms for Sustainable Civil Engineering* | **4** | **5** | **-** | **1** |
| **PC42.** Understand AI algorithms analyze building designs and materials to optimize energy efficiency. | - | - | - | - |
| **PC43.** Discuss AI tools in selecting sustainable building materials by evaluating factors such as environmental impact, lifecycle analysis, and cost-effectiveness. | - | - | - | - |
| **PC44.** Decribe AI tools enhance waste management in construction projects by predicting waste generation patterns and optimizing recycling processes. | - | - | - | - |
| **PC45.** Understand AI algorithms model and manage water usage in construction projects, ensuring efficient water consumption and minimizing waste. | - | - | - | - |
| **PC46.** Explain AI tools analyze climate data to model the impact of environmental changes on infrastructure. | - | - | - | - |
| *Advancement in AI for Civil Engineering* | **4** | **5** | **-** | **1** |
| **PC47.** Explain AI-driven generative design tools allow engineers to explore a wide range of design alternatives quickly. | - | - | - | - |
| **PC48.** Understand advanced machine learning algorithms analyze data from sensors embedded in structures to detect anomalies and predict maintenance needs. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC49.** Describe AI applications utilizing natural language processing (NLP) help civil engineers navigate complex regulatory documents and codes. | - | - | - | - |
| **PC50.** Explain AI algorithms analyze vast datasets related to environmental conditions, enabling more accurate predictions of a project’s ecological impact. | - | - | - | - |
| **PC51.** Understand advances in AI-powered robotics are transforming construction sites, enabling automated tasks such as bricklaying, welding, and excavation. | - | - | - | - |
| **PC52.** Explore AI technologies are essential for developing smart cities, where civil engineering projects are inter-connected through IoT devices. | - | - | - | - |
| **NOS Total** | **40** | **50** | **-** | **10** |

## National Occupational Standards (NOS) Parameters

| | |
|---|---|
| **NOS Code** | ICE/ITS/N0208 |
| **NOS Name** | Applications of AI tools/algorithms in Civil Engineering |
| **Sector** | Information Technology Sector |
| **Sub-Sector** | |
| **Occupation** | Artificial Intelligence |
| **NSQF Level** | 5 |
| **Credits** | 10 |
| **Version** | 1.0 |
| **Last Reviewed Date** | 17/12/2024 |
| **Next Review Date** | 17/12/2027 |
| **NSQC Clearance Date** | 17/12/2024 |

# ICE/ITS/N0209: Applications of AI tools/algorithms in Metallurgical and Materials Engineering

## Description

This module encompasses the applications of AI tools in Metallurgical and Materials Engineering enhance material properties, optimize processes, and facilitate the design of advanced materials through data-driven methodologies.

## Scope

The scope covers the following :

- Focuses on developing new materials using AI algorithms.
- Aims to improve efficiency in material processing.
- Explain material structure for better performance prediction.
- Forecasts material behavior under various conditions.
- Integrates AI with Industry 4.0 for advanced manufacturing processes.
- Enhances recycling processes for a circular economy in materials usage.

## Elements and Performance Criteria

### *Use AI tools/algorithms for Materials Design*

To be competent, the user/individual on the job must be able to:

**PC1.** Explain AI algorithms analyze large datasets of material properties and structures to identify promising for new materials.

**PC2.** Understand machine learning models predict the mechanical, thermal, and electrical properties of materials based on their composition and microstructure.

**PC3.** Discuss AI tools optimize the compositions of metal alloys by simulating different combinations of elements and predicting their performance, enhancing the development of high- strength, lightweight, and corrosion-resistant materials.

**PC4.** Describe AI algorithms are employed to design and control the microstructure of materials during processing (e.g., casting, forging, or additive manufacturing), leading to improved mechanical properties and performance.

**PC5.** Understand AI tools in designing materials specifically for additive manufacturing processes by optimizing the geometry and material properties, thus ensuring better manufacturability and performance in 3D-printed components.

**PC6.** Explore AI algorithms to analyze historical data from materials testing and operational environments to predict failure modes and enhance the durability and reliability of materials under various loading conditions.

### *Utilize Process Optimization and Control in Metallurgy*

To be competent, the user/individual on the job must be able to:

**PC7.** Discuss AI algorithms integrated into metallurgical processes to monitor parameters such as temperature, pressure, and chemical composition in real-time.

**PC8.** Describe machine learning models, metallurgical plants predict equipment failures.

**PC9.** Discuss AI tools analyze historical process data to identify optimal settings for various parameters (e.g., heating rates, cooling rates, and material flow), resulting in enhanced efficiency, reduced energy consumption, and improved yield.

**PC10.** Understand advanced AI-driven simulations model complex metallurgical processes, such as casting, welding, and heat treatment.

**PC11.** Explain AI algorithms be trained to detect defects in materials and products through image analysis or sensor data, ensuring high quality and consistency in metallurgical output by automating quality control processes.

**PC12.** Discuss AI tools optimize the flow of materials through the production process, enhancing logistics and inventory management, reducing waste, and improving overall operational efficiency in metallurgical operations.

*Use Computational Techniques in Microstructure Analysis*

To be competent, the user/individual on the job must be able to:

**PC13.** Discuss AI algorithms automate the analysis of microstructural images obtained from microscopy techniques, such as electron microscopy (SEM) and transmission electron microscopy (TEM), enabling faster and more accurate identification of phase distributions, grain boundaries, and defects.

**PC14.** Understand Computational techniques, including machine learning and image processing, quantitatively characterize microstructural features, such as grain size, shape, and orientation, facilitating a deeper understanding of microstructure affects material properties and performance.

**PC15.** Explain AI tools to develop models that simulate microstructural evolution during processes like solidification, heat treatment, and deformation, allowing researchers to predict changes in processing conditions affect microstructure and resulting material properties.

**PC16.** Discuss microstructure data with materials property databases, AI tools identify correlations between microstructural features and mechanical, thermal, or electrical properties, aiding in the design of materials with tailored performance characteristics.

**PC17.** Explain machine learning algorithms to be trained on existing datasets to predict microstructural outcomes based on processing parameters.

**PC18.** Understand AI-powered visualization techniques to analyze complex microstructures, enabling better understanding and interpretation of material.

*Utilize AI tools/algorithms for Predictive Modelling of Material Behaviour*

To be competent, the user/individual on the job must be able to:

**PC19.** Discuss AI tools leverage large datasets obtained from experimental and simulation studies to understand create predictive models.

**PC20.** Understand machine learning algorithms, such as regression analysis, decision trees, and neural networks, facilitate the development of robust models that accurately predict mechanical properties, fatigue life, and failure modes of materials.

**PC21.** Explain predictive modelling help optimize processing parameters (e.g., temperature, pressure, and time) to enhance material properties and AI algorithms identify the best processing routes to achieve desired characteristics like strength, ductility, or corrosion resistance.

**PC22.** Understand AI with finite element analysis (FEA) and other computational mechanics tools enables the simulation of complex material behavior under real-world conditions.

*Use AI tools/algorithms Utilize in Smart Manufacturing and Industry 4.0*

To be competent, the user/individual on the job must be able to:

**PC23.** Discuss AI algorithms enable real-time monitoring of manufacturing processes by analyzing data from sensors and IoT devices. This facilitates immediate adjustments to optimize conditions, improve quality, and reduce waste in metallurgical processes.

**PC24.** Understand AI tools for predictive maintenance helps anticipate equipment failures and schedule maintenance proactively.

**PC25.** Decsribe machine learning models analyze operational data to identify patterns indicating potential breakdowns, thereby minimizing downtime and increasing productivity.

**PC26.** Explain AI algorithms analyze complex datasets to optimize metallurgical processes such as casting, welding, and heat treatment.

**PC27.** Understand AI tools streamline supply chain operations by predicting demand, optimizing inventory levels, and managing logistics.

**PC28.** Explain AI algorithms enhance quality control processes through advanced image recognition and anomaly detection.

### *Utilize AI in Materials Recycling and Circular Economy*

To be competent, the user/individual on the job must be able to:

**PC29.** Understand AI algorithms enhance the efficiency of sorting recyclable materials by using computer vision and machine learning techniques to identify different types of metals and materials.

**PC30.** Explain AI optimizes recycling processes by analyzing data from various stages of material recovery.

**PC31.** Explain AI-driven predictive modeling forecast the yield of recycled materials from various waste streams.

**PC32.** Understand AI tools in the design and development of sustainable materials.

**PC33.** Discuss AI algorithms support the implementation of circular economy strategies by analyzing data on resource flows, usage patterns, and waste generation.

### *Advancement in AI for Metallurgy and Materials*

To be competent, the user/individual on the job must be able to:

**PC34.** Explain AI algorithms significantly speed up the discovery of new materials by predicting their properties based on existing data, allowing metallurgists to identify for specific applications.

**PC35.** Understand advanced AI tools are employed to optimize metallurgical processes, such as casting, forging, and heat treatment, by analyzing large datasets to find the best parameters that enhance yield, reduce waste, and improve product quality.

**PC36.** Explore AI-powered systems enable real-time monitoring of metallurgical processes, providing insights and alerts about deviations from optimal conditions quality and reducing defects.

**PC37.** Understand machine learning algorithms to analyze equipment performance data, metallurgical facilities anticipate equipment failures and schedule maintenance, minimizing downtime and extending machinery lifespan.

**PC38.** Explain AI tools facilitate complex simulations of metallurgical processes, allowing engineers to model and predict different variables affect material performance.

**PC39.** Discuss advancement of AI tools aligns with Industry 4.0 initiatives.

## Knowledge and Understanding (KU)

The individual on the job needs to know and understand:

**KU1.** AI algorithms analyze historical data to predict the properties of new materials based on their composition and processing conditions, streamlining the materials development process.

**KU2.** Data analytics tools allow engineers to make informed decisions based on empirical evidence, enhancing the design and optimization of metallurgical processes.

**KU3.** Machine learning methods such as supervised and unsupervised learning helps metallurgical engineers identify patterns in data that lead to improved material performance and process efficiency.

**KU4.** AI tools enable the analysis of microstructural images, allowing for the identification of defects and the correlation of microstructure with material properties, crucial for quality assurance in materials manufacturing.

**KU5.** Optimization algorithms (e.g., genetic algorithms, gradient descent) are essential for enhancing metallurgical processes by finding the best parameters that maximize performance and minimize costs.

**KU6.** Awareness of AI integrates with smart manufacturing concepts, such as IoT and Industry 4.0, enables metallurgical engineers to implement technologies that enhance process automation and data collection.

**KU7.** AI tools to be applied to improve recycling processes and develop sustainable materials contribute to reducing the environmental impact of metallurgical practices.

## Generic Skills (GS)

User/individual on the job needs to know how to:

**GS1.** Listen and communicate effectively and accurately.

**GS2.** Apply problem-solving approaches for different situations.

**GS3.** Work effectively in a team.

**GS4.** Employ proper time management.

**GS5.** Plan and organize work.

**GS6.** Maintain hygiene and sanitation.

**GS7.** Analytical skills

## Assessment Criteria

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| *Use AI tools/algorithms for Materials Design* | **6** | **7** | **-** | **2** |
| **PC1.** Explain AI algorithms analyze large datasets of material properties and structures to identify promising for new materials. | - | - | - | - |
| **PC2.** Understand machine learning models predict the mechanical, thermal, and electrical properties of materials based on their composition and microstructure. | - | - | - | - |
| **PC3.** Discuss AI tools optimize the compositions of metal alloys by simulating different combinations of elements and predicting their performance, enhancing the development of high- strength, lightweight, and corrosion-resistant materials. | - | - | - | - |
| **PC4.** Describe AI algorithms are employed to design and control the microstructure of materials during processing (e.g., casting, forging, or additive manufacturing), leading to improved mechanical properties and performance. | - | - | - | - |
| **PC5.** Understand AI tools in designing materials specifically for additive manufacturing processes by optimizing the geometry and material properties, thus ensuring better manufacturability and performance in 3D-printed components. | - | - | - | - |
| **PC6.** Explore AI algorithms to analyze historical data from materials testing and operational environments to predict failure modes and enhance the durability and reliability of materials under various loading conditions. | - | - | - | - |
| *Utilize Process Optimization and Control in Metallurgy* | **6** | **8** | **-** | **2** |
| **PC7.** Discuss AI algorithms integrated into metallurgical processes to monitor parameters such as temperature, pressure, and chemical composition in real-time. | - | - | - | - |
| **PC8.** Describe machine learning models, metallurgical plants predict equipment failures. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC9.** Discuss AI tools analyze historical process data to identify optimal settings for various parameters (e.g., heating rates, cooling rates, and material flow), resulting in enhanced efficiency, reduced energy consumption, and improved yield. | - | - | - | - |
| **PC10.** Understand advanced AI-driven simulations model complex metallurgical processes, such as casting, welding, and heat treatment. | - | - | - | - |
| **PC11.** Explain AI algorithms be trained to detect defects in materials and products through image analysis or sensor data, ensuring high quality and consistency in metallurgical output by automating quality control processes. | - | - | - | - |
| **PC12.** Discuss AI tools optimize the flow of materials through the production process, enhancing logistics and inventory management, reducing waste, and improving overall operational efficiency in metallurgical operations. | - | - | - | - |
| *Use Computational Techniques in Microstructure Analysis* | **6** | **7** | **-** | **2** |
| **PC13.** Discuss AI algorithms automate the analysis of microstructural images obtained from microscopy techniques, such as electron microscopy (SEM) and transmission electron microscopy (TEM), enabling faster and more accurate identification of phase distributions, grain boundaries, and defects. | - | - | - | - |
| **PC14.** Understand Computational techniques, including machine learning and image processing, quantitatively characterize microstructural features, such as grain size, shape, and orientation, facilitating a deeper understanding of microstructure affects material properties and performance. | - | - | - | - |
| **PC15.** Explain AI tools to develop models that simulate microstructural evolution during processes like solidification, heat treatment, and deformation, allowing researchers to predict changes in processing conditions affect microstructure and resulting material properties. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC16.** Discuss microstructure data with materials property databases, AI tools identify correlations between microstructural features and mechanical, thermal, or electrical properties, aiding in the design of materials with tailored performance characteristics. | - | - | - | - |
| **PC17.** Explain machine learning algorithms to be trained on existing datasets to predict microstructural outcomes based on processing parameters. | - | - | - | - |
| **PC18.** Understand AI-powered visualization techniques to analyze complex microstructures, enabling better understanding and interpretation of material. | - | - | - | - |
| *Utilize AI tools/algorithms for Predictive Modelling of Material Behaviour* | **6** | **7** | **-** | **1** |
| **PC19.** Discuss AI tools leverage large datasets obtained from experimental and simulation studies to understand create predictive models. | - | - | - | - |
| **PC20.** Understand machine learning algorithms, such as regression analysis, decision trees, and neural networks, facilitate the development of robust models that accurately predict mechanical properties, fatigue life, and failure modes of materials. | - | - | - | - |
| **PC21.** Explain predictive modelling help optimize processing parameters (e.g., temperature, pressure, and time) to enhance material properties and AI algorithms identify the best processing routes to achieve desired characteristics like strength, ductility, or corrosion resistance. | - | - | - | - |
| **PC22.** Understand AI with finite element analysis (FEA) and other computational mechanics tools enables the simulation of complex material behavior under real-world conditions. | - | - | - | - |
| *Use AI tools/algorithms Utilize in Smart Manufacturing and Industry 4.0* | **6** | **7** | **-** | **1** |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC23.** Discuss AI algorithms enable real-time monitoring of manufacturing processes by analyzing data from sensors and IoT devices. This facilitates immediate adjustments to optimize conditions, improve quality, and reduce waste in metallurgical processes. | - | - | - | - |
| **PC24.** Understand AI tools for predictive maintenance helps anticipate equipment failures and schedule maintenance proactively. | - | - | - | - |
| **PC25.** Decsribe machine learning models analyze operational data to identify patterns indicating potential breakdowns, thereby minimizing downtime and increasing productivity. | - | - | - | - |
| **PC26.** Explain AI algorithms analyze complex datasets to optimize metallurgical processes such as casting, welding, and heat treatment. | - | - | - | - |
| **PC27.** Understand AI tools streamline supply chain operations by predicting demand, optimizing inventory levels, and managing logistics. | - | - | - | - |
| **PC28.** Explain AI algorithms enhance quality control processes through advanced image recognition and anomaly detection. | - | - | - | - |
| *Utilize AI in Materials Recycling and Circular Economy* | **5** | **7** | **-** | **1** |
| **PC29.** Understand AI algorithms enhance the efficiency of sorting recyclable materials by using computer vision and machine learning techniques to identify different types of metals and materials. | - | - | - | - |
| **PC30.** Explain AI optimizes recycling processes by analyzing data from various stages of material recovery. | - | - | - | - |
| **PC31.** Explain AI-driven predictive modeling forecast the yield of recycled materials from various waste streams. | - | - | - | - |
| **PC32.** Understand AI tools in the design and development of sustainable materials. | - | - | - | - |

| Assessment Criteria for Outcomes | Theory Marks | Practical Marks | Project Marks | Viva Marks |
|---|---|---|---|---|
| **PC33.** Discuss AI algorithms support the implementation of circular economy strategies by analyzing data on resource flows, usage patterns, and waste generation. | - | - | - | - |
| *Advancement in AI for Metallurgy and Materials* | **5** | **7** | **-** | **1** |
| **PC34.** Explain AI algorithms significantly speed up the discovery of new materials by predicting their properties based on existing data, allowing metallurgists to identify for specific applications. | - | - | - | - |
| **PC35.** Understand advanced AI tools are employed to optimize metallurgical processes, such as casting, forging, and heat treatment, by analyzing large datasets to find the best parameters that enhance yield, reduce waste, and improve product quality. | - | - | - | - |
| **PC36.** Explore AI-powered systems enable real-time monitoring of metallurgical processes, providing insights and alerts about deviations from optimal conditions quality and reducing defects. | - | - | - | - |
| **PC37.** Understand machine learning algorithms to analyze equipment performance data, metallurgical facilities anticipate equipment failures and schedule maintenance, minimizing downtime and extending machinery lifespan. | - | - | - | - |
| **PC38.** Explain AI tools facilitate complex simulations of metallurgical processes, allowing engineers to model and predict different variables affect material performance. | - | - | - | - |
| **PC39.** Discuss advancement of AI tools aligns with Industry 4.0 initiatives. | - | - | - | - |
| **NOS Total** | **40** | **50** | **-** | **10** |

## National Occupational Standards (NOS) Parameters

| | |
|---|---|
| **NOS Code** | ICE/ITS/N0209 |
| **NOS Name** | Applications of AI tools/algorithms in Metallurgical and Materials Engineering |
| **Sector** | Information Technology Sector |
| **Sub-Sector** | |
| **Occupation** | Artificial Intelligence |
| **NSQF Level** | 5 |
| **Credits** | 10 |
| **Version** | 1.0 |
| **Last Reviewed Date** | 17/12/2024 |
| **Next Review Date** | 17/12/2027 |
| **NSQC Clearance Date** | 17/12/2024 |

# Assessment Guidelines and Assessment Weightage

## Assessment Guidelines

Criteria for assessment for each Qualification Pack will be created by the Awarding Body. Each Performance Criteria (PC)/ Element will be assigned marks proportional to its importance in NOS. AB will also lay down proportion of marks for Theory and Skills Practical for each PC/ Element.

2. The assessment for the knowledge part will be based on knowledge bank of questions created by Assessment Bodies subject to approval by AB

3. Individual assessment agencies will create unique question papers for knowledge/theory part for assessment of candidates as per assessment criteria given below

4. Individual assessment agencies will create unique evaluations for skill practical for every student at each examination/training center based on assessment criteria.

5. The passing percentage for each QP will be 70%. To pass the Qualification Pack, every trainee should score a minimum of 70% individually in each NOS.

6. The Assessor shall check the final outcome of the practices while evaluating the steps performed to achieve the final outcome.

7. The trainee shall be provided with a chance to repeat the test to correct his procedures in case of improper performance, with a deduction of marks for each iteration.

8. After the certain number of iterations as decided by AB the trainee is marked as fail, scoring zero marks for the procedure for the practical activity.

9. In case of successfully passing only certain number of NOS's, the trainee is eligible to take subsequent assessment on the balance NOS's to pass the Qualification Pack within the specified time frame set by AB.

10. Minimum duration of Assessment of each QP shall be of 4hrs/trainee

**Minimum Aggregate Passing % at QP Level : 70**

(**Please note**: Every Trainee should score a minimum aggregate passing percentage as specified above, to successfully clear the Qualification Pack assessment.)

## Assessment Weightage

Compulsory NOS

| National Occupational Standards | Theory Marks | Practical Marks | Project Marks | Viva Marks | Total Marks | Weightage |
|---|---|---|---|---|---|---|
| ICE/ITS/N0201.Fundamentals of Artificial Intelligence (AI) | 40 | 50 | 0 | 10 | 100 | 15 |
| ICE/ITS/N0202.Python Programming and data science for AI | 40 | 50 | 0 | 10 | 100 | 30 |
| ICE/ITS/N0203.Building Blocks of Artificial Intelligence (A.I) | 40 | 50 | - | 10 | 100 | 15 |
| DGT/VSQ/N0102.Employability Skills (60 Hours) | 20 | 30 | - | - | 50 | 10 |
| **Total** | **140** | **180** | **-** | **30** | **350** | **70** |

Elective: 1 Application in CS & IT Domain

| National Occupational Standards | Theory Marks | Practical Marks | Project Marks | Viva Marks | Total Marks | Weightage |
|---|---|---|---|---|---|---|
| ICE/ITS/N0204.Applications of AI tools/algorithms in Computer Science and Information Technology Engineering | 40 | 50 | 0 | 10 | 100 | 30 |
| **Total** | **40** | **50** | **-** | **10** | **100** | **30** |

Elective: 2 Applications of AI in ECE Domain

| National Occupational Standards | Theory Marks | Practical Marks | Project Marks | Viva Marks | Total Marks | Weightage |
|---|---|---|---|---|---|---|
| ICE/ITS/N0205.Applications of AI tools/algorithms in Electronics & Communication Engineering | 40 | 50 | 0 | 10 | 100 | 30 |
| **Total** | **40** | **50** | **-** | **10** | **100** | **30** |

Elective: 3 Applications of AI in Electrical Domain

| National Occupational Standards | Theory Marks | Practical Marks | Project Marks | Viva Marks | Total Marks | Weightage |
|---|---|---|---|---|---|---|
| ICE/ITS/N0206.Applications of AI tools/algorithms in Electrical Engineering | 40 | 50 | 0 | 10 | 100 | 30 |
| **Total** | **40** | **50** | **-** | **10** | **100** | **30** |

Elective: 4 Applications of AI in Mechanical Domain

| National Occupational Standards | Theory Marks | Practical Marks | Project Marks | Viva Marks | Total Marks | Weightage |
|---|---|---|---|---|---|---|
| ICE/ITS/N0207.Applications of AI tools/algorithms in Mechanical Engineering | 40 | 50 | 0 | 10 | 100 | 30 |
| **Total** | **40** | **50** | **-** | **10** | **100** | **30** |

Elective: 5 Applications of AI in Civil Domain

| National Occupational Standards | Theory Marks | Practical Marks | Project Marks | Viva Marks | Total Marks | Weightage |
|---|---|---|---|---|---|---|
| ICE/ITS/N0208.Applications of AI tools/algorithms in Civil Engineering | 40 | 50 | 0 | 10 | 100 | 30 |
| **Total** | **40** | **50** | **-** | **10** | **100** | **30** |

Elective: 6 Applications of AI in Metallurgy Domain

| National Occupational Standards | Theory Marks | Practical Marks | Project Marks | Viva Marks | Total Marks | Weightage |
|---|---|---|---|---|---|---|
| ICE/ITS/N0209.Applications of AI tools/algorithms in Metallurgical and Materials Engineering | 40 | 50 | 0 | 10 | 100 | 30 |
| **Total** | **40** | **50** | **-** | **10** | **100** | **30** |

## Acronyms

| | |
|---|---|
| **NOS** | National Occupational Standard(s) |
| **NSQF** | National Skills Qualifications Framework |
| **QP** | Qualifications Pack |
| **TVET** | Technical and Vocational Education and Training |
| **HVAC** | Heating, Ventilation Air Conditioning |
| **BIM** | BIM Building Information Modelling |
| **A.I** | Artificial Intelligence |
| **CNN** | Convolutional Neural Network |
| **IoT** | Internet of Things |
| **CV** | Computer Vision |
| **YOLO** | You Only Look Once |
| **GDPR** | General Data Protection Regulation |
| **OSHA** | Occupational Safety and Health Administration |
| **NLP** | Natural Language Processing |
| **GPS** | Global Positioning System |
| **GPR** | Global Positioning Radar |
| **RFID** | Radio Frequency Identification |
| **RNN** | Recurrent Neural Networks |

## Glossary

| | |
|---|---|
| **Sector** | Sector is a conglomeration of different business operations having similar business and interests. It may also be defined as a distinct subset of the economy whose components share similar characteristics and interests. |
| **Sub-sector** | Sub-sector is derived from a further breakdown based on the characteristics and interests of its components. |
| **Occupation** | Occupation is a set of job roles, which perform similar/ related set of functions in an industry. |
| **Job role** | Job role defines a unique set of functions that together form a unique employment opportunity in an organisation. |
| **Occupational Standards (OS)** | OS specify the standards of performance an individual must achieve when carrying out a function in the workplace, together with the Knowledge and Understanding (KU) they need to meet that standard consistently. Occupational Standards are applicable both in the Indian and global contexts. |
| **Performance Criteria (PC)** | Performance Criteria (PC) are statements that together specify the standard of performance required when carrying out a task. |
| **National Occupational Standards (NOS)** | NOS are occupational standards which apply uniquely in the Indian context. |
| **Qualifications Pack (QP)** | QP comprises the set of OS, together with the educational, training and other criteria required to perform a job role. A QP is assigned a unique qualifications pack code. |
| **Unit Code** | Unit code is a unique identifier for an Occupational Standard, which is denoted by an 'N' |
| **Unit Title** | Unit title gives a clear overall statement about what the incumbent should be able to do. |
| **Description** | Description gives a short summary of the unit content. This would be helpful to anyone searching on a database to verify that this is the appropriate OS they are looking for. |
| **Scope** | Scope is a set of statements specifying the range of variables that an individual may have to deal with in carrying out the function which have a critical impact on quality of performance required. |

| | |
|---|---|
| **Knowledge and Understanding (KU)** | Knowledge and Understanding (KU) are statements which together specify the technical, generic, professional and organisational specific knowledge that an individual needs in order to perform to the required standard. |
| **Organisational Context** | Organisational context includes the way the organisation is structured and how it operates, including the extent of operative knowledge managers have of their relevant areas of responsibility. |
| **Technical Knowledge** | Technical knowledge is the specific knowledge needed to accomplish specific designated responsibilities. |
| **Core Skills/ Generic Skills (GS)** | Core skills or Generic Skills (GS) are a group of skills that are the key to learning and working in today's world. These skills are typically needed in any work environment in today's world. These skills are typically needed in any work environment. In the context of the OS, these include communication related skills that are applicable to most job roles. |
| **Electives** | Electives are NOS/set of NOS that are identified by the sector as contributive to specialization in a job role. There may be multiple electives within a QP for each specialized job role. Trainees must select at least one elective for the successful completion of a QP with Electives. |
| **Options** | Options are NOS/set of NOS that are identified by the sector as additional skills. There may be multiple options within a QP. It is not mandatory to select any of the options to complete a QP with Options. |