BACHELOR OF TECHNOLOGY

METALLURGICAL ENGINEERING / METALLURGY & MATERIALS ENGINEERING

SECOND YEAR (FOURTH SEMESTER)

W.E.F. ADMISSION BATCH 2023-24

Sl. No.	Category	Course Code	Course	Contact Hrs. L-T-P	Credit	University Marks	Internal Evaluation
Subject (Theory)							
1	PC	MTPC2004	Transport Phenomena	3-0-0	3	100	50
2	PC	MTPC2005	Phase Transformation & Heat Treatment of Metals	3-0-0	3	100	50
3	PC	MTPC2006	Deformation Behavior of Materials	3-0-0	3	100	50
4	PC	MTPC2007	Iron Making and Steel Making	3-0-0	3	100	50
5	PC(ACC)	PCAC2008	Machine Learning Techniques and Applications	3-0-0	2	100	50
		PCAC2009	Big Data Integration and Management				
		PCAC2010	Application Development – Tools & Technologies				
		PCAC2011	Cloud Infrastructure & Applications				
		PCAC2012	Internet of Things and Cloud				
		PCAC2013	Robotics : Mobility & Design				
		PCAC2014	IT Fundamentals for Cybersecurity – II				
6	HS	HSHS2002	Organizational Behaviour	3-0-0	2	100	50
		HSHS2001	Engineering Economics				
Subject (Sessional / Practical)							
7	PC	MTPC2204	Transport Phenomena Lab.	0-0-3	1.5	–	100
8	PC	MTPC2205	Phase Transformation & Heat Treatment of Metals Lab.	0-0-3	1.5	–	100
9	PC	MTPC2206	Deformation Behavior & Mechanical Testing Lab.	0-0-3	1.5	–	100
10	PC	MTPC2207	Modeling of Process Metallurgy Lab.	0-0-3	1.5	–	100
			Total	**18-0-12**	**22**	**600**	**700**

Note : Minimum four (04) weeks of Summer Course / Training / Internship / Skill Course / etc. after 4th Semester.

Click here to view/download the syllabus of the subjects.

HSHS2002 ORGANISATIONAL BEHAVIOUR (3-0-0)

Objectives:
The objective is to develop an understanding of the behavior of individuals and groups inside organizations and to enhance skills in understanding and appreciating individuals, interpersonal, and group process for increased effectiveness both within and outside of organizations. Further, it is to develop theoretical and practical insights and problem-solving capabilities for effectively managing the organizational processes.

Module-I: (06 Hrs.)
Fundamentals of OB: Definition, scope and importance of OB, Relationship between OB and the individual, Evolution of OB, Theoretical framework (cognitive), behavioristic and social cognitive), Limitations of OB.

Module-II: (12 Hrs.)
Attitude: Importance of attitude in an organization, Right Attitude, Components of attitude, Relationship between behavior and attitude, Developing Emotional intelligence at the workplace, Job attitude, Barriers to changing attitudes.
Personality and values: Definition and importance of Personality for performance, The Myers-Briggs Type Indicator and The Big Five personality model, Significant personality traits suitable to the workplace (personality and job — fit theory), Personality Tests and their practical applications.
Perception: Meaning and concept of perception, Factors influencing perception, Selective perception, Attribution theory, Perceptual process, Social perception (stereotyping and halo effect).Motivation: Definition & Concept of Motive & Motivation, The Content Theories of Motivation(Maslow's Need Hierarchy & Herzberg's Two Factor model Theory), The Process Theories (Vroom's expectancy Theory & Porter Lawler model), Contemporary Theories — Equity Theory of Work Motivation.

Module-III: (10 Hrs.)
Foundations of Group Behavior: The Meaning of Group & Group behavior & Group Dynamics, Types of Groups, The Five — Stage Model of Group Development.
Managing Teams: Why Work Teams, Work Teams in Organization, Developing Work Teams, Team Effectiveness & Team Building.
Leadership: Concept of Leadership, Styles of Leadership, Trait Approach Contingency Leadership Approach, Contemporary leadership, Meaning and significance of contemporary leadership, Concept of transformations leadership, Contemporary theories of leadership, Success stories of today's Global and Indian leaders.

Module-IV: (08 Hrs.)
Organizational Culture : Meaning & Definition of Organizational Culture, creating & Sustaining Organizational Culture, Types of Culture (Strong vs. Weak Culture, Soft Vs. Hard Culture & Formal vs. Informal Culture), Creating Positive Organizational Culture, Concept of Workplace Spirituality.

Module-V: (09 Hrs.)
Organizational Change: Meaning, Definition & Nature of Organizational Change, Types of Organizational Change, Forces that acts as stimulants to change.
Implementing Organizational Change : How to overcome theResistance to Change,
Approaches to managing Organizational Change, Kurt Lewin's-Three step model, Seven Stage model of Change & Kotter's Eight-Step plan for Implementing Change, Leading the Change Process, Facilitating Change, Dealing with Individual & Group Resistance, Intervention Strategies for Facilitating Organizational Change, Methods of Implementing Organizational Change, Developing a Learning Organization.

Course Outcomes:
At the end of the course, students will be able to:
1. Understand the basic concepts of OB, change management, organizational culture and their implementation in organizations.
2. Identify and examine team characteristics for improved organizational performance.
3. Apply theories and frameworks to solve problems and take effective decisions for organizational success.
4. Analyze group behavior and leadership styles for effective people management.

5. Evaluate individual personality types and group behaviours for improving organizational processes and practices.
6. Develop leadership competency to manage organizational situations.

Books:

1. Understanding Organizational Behaviour, Parek, Oxford
2. Organizational Behaviour, Robbins, Judge, Sanghi, Pearson.
3. Organizational Behaviour, K. Awathappa,HPH.
4. Organizational Behaviour, VSP Rao, Excel
5. Introduction to Organizational Behaviour, Moorhead, Griffin, Cengage.
6. Organizational Behaviour, Hitt, Miller, Colella, Wiley.

MTPC2004 TRANSPORT PHENOMENA (3-0-0)

Course Objective:

1. To develop a thorough understanding of the principles of momentum, heat, and mass transfer, and their interrelation in various engineering systems.
2. To enable students to analyze and solve practical problems in fluid flow, heat transfer, and mass transfer, with applications in industrial processes, including flow measurement, packed and fluidized beds, conduction, convection, radiation, and diffusion.

Module I (6 Hrs)

Classification of fluids, ideal & real, Newtonian & Non-Newtonian, Newton's law of viscosity. Types of fluid flow – streamline & turbulent, continuity equation for incompressible and compressible fluid and its application. Concept of velocity bounds layer.; Bernoulli's equation and its application for flow measurement by venturimeter, orifice meter, pilot tube and rotameter.

Module-II (6 Hrs)

Pressure drop & friction factor in various configurations, flow in packed bed & fluidized bed, Dimensional analysis by Rayleigh's method of indices and Buckingham's π theorem. Example of analysis of pressure gradient, mass transfer co-efficient & convective heat transfer co-efficient, concept of similarly and dimensionless criteria. Dimensionless groups & their significance.

Module III (6 Hrs)

Internal & External modes of heat transfer, steady state heat conduction in monolayer and composite flat walls & cylinders. Numerical related to steady state heat conduction. Unsteady state heat conduction, thin & massive body heating & cooling. Finite difference method in solving unsteady state heat conduction.

Module IV (6 Hrs)

Natural and forced convection, concept of heat transfer co-efficient, thermal boundary layers, some examples of connective co-relations. Types of flow: Counter flow, parallel flow and cross flow with derivation. Overall Heat transfer co-efficient. Law of radiation – Steffan-Boltzmann's law, Kirchoff's law &Lambarth's law, Black & grey body concepts, view factor, Radiation from flames & gases. Radiation between simple surfaces with & without absorbing gas media. Radiation shields.

Module V (6 Hrs)

Mass Transfer: Law of diffusion and their application, concept of mass transfer coefficient & concentration boundary layer, Interfacial mass transfer, overall mass balance.

Course Outcome:

CO1: Students will understand the classification of fluids, flow types, and applications of Bernoulli's equation for flow measurement using devices like venturimeter, orifice meter, and rotameter. They will also analyze velocity boundary layers and fluid behavior in different conditions.

CO2: Students will learn to analyze pressure drops and friction factors in various configurations, including packed and fluidized beds. They will gain skills in dimensional analysis using Rayleigh's and Buckingham's π methods, along with understanding dimensionless groups and their significance.

CO3: Students will gain knowledge of steady and unsteady-state heat conduction in monolayer and composite structures and solve related numerical problems. They will also use finite difference methods for solving unsteady-state heat conduction problems

CO4: Students will understand natural and forced convection principles, thermal boundary layers, and various flow types (counter, parallel, cross). They will also study radiation laws, black and grey body concepts, radiation between surfaces, and radiation shields

CO5: Students will learn the laws of diffusion, the concept of mass transfer coefficients, and interfacial mass transfer. They will apply these principles to solve problems involving concentration boundary layers and overall mass balances in industrial processes.

Text Books:

1. Transport Phenomena by R. B. Bird, W. E. Stewart and E. N. Lightfoot, Wiley, 1960
2. Rate Processes in Metallurgy by A. K. Mohanty, PHI
3. Transport Phenomena in Metallurgy by G. H. Geiger and D. R. Poirier, Addison-Wesley, 1973.
4. Rate Phenomena in Process Metallurgy by J. Szekely and N. J. Themelis

Reference Books:

1. Rate Phenomena in Process Metallurgy by J. Szekely and N. J. Themelis
2. J. R. Welty, R. E. Wilson and C. E. Wicks, Fundamentals of Momentum Heat and Mass Transfer, Wiley, 1976

MTPC2005 PHASE TRANSFORMATION AND HEAT TREATMENT OF METALS (3-0-0)

Course Objective:

1. To provide students with a comprehensive understanding of the thermodynamic and kinetic principles governing phase transformations in materials, including nucleation, growth, and the role of phase diagrams in predicting microstructural evolution.
2. To equip students with the knowledge and practical skills required to design and apply heat treatment techniques, such as annealing, quenching, tempering, and surface hardening, to achieve desired mechanical and microstructural properties in metals and alloys.

Module I (6 Hrs)

Introduction: Definition and types of Phase transformations, Free Energy for Ideal solution and regular solution, free energy composition diagrams, Spinodal decomposition, Miscibility gap; Ternary Phase Diagram.

Module-II (6 Hrs)

Order-disorder Transformation examples of ordered structures, long range and short range order. influence of ordering on properties. Crystal interfaces and microstructure. Microstructure evolution including recrystallization and grain growth.

Module III (6 Hrs)

Review of Iron-carbon alloy system, Graphitization, Importance of Austenite Grain size. Formation of Austenite, Pearlitic, Bainitic and Martensitic Transformations (Mechanisms, Kinetics and Morphologies)

Module IV (6 Hrs)

Heat treatment of steels: TTT and CCT diagrams, conventional heat treatment processes – annealing, normalizing, hardening and tempering. Hardenability, Factors influencing hardenability, Methodology.

Module V (6 Hrs)

Surface heat Treatment Process: Heat treatment of non-ferrous alloys (Al-Cu, brass, Ti alloys, Ni alloys), Heat treatment of special steel(maraging steel, HSLA)

Course Outcome:

CO1: Students will be able to explain the fundamental concepts of phase transformations, interpret free energy diagrams, and analyze spinodal decomposition, miscibility gaps, and ternary phase diagrams.
CO2: Students will understand order-disorder transformations, evaluate their influence on material properties, and analyze microstructure evolution processes such as recrystallization and grain growth.
CO3: Students will demonstrate the ability to analyze the iron-carbon system, understand graphitization, and describe pearlitic, bainitic, and martensitic transformations in terms of mechanisms, kinetics, and morphologies.
CO4: Students will gain the skills to interpret TTT and CCT diagrams, design conventional heat treatment processes, and evaluate factors influencing the hardenability of steels.
CO5: Students will be able to apply surface heat treatment processes, understand heat treatment techniques for non-ferrous alloys, and analyze the treatment of special steels like maraging steel and HSLA.

Text Books:

1. "Phase Transformations in Metals and Alloys" by David A. Porter, Kenneth E. Easterling, and Mohamed Sherif
2. "Heat Treatment: Principles and Techniques" by T.V. Rajan, C.P. Sharma, and Ashok Sharma

Reference Books:

1. "Physical Metallurgy Principles" by Robert E. Reed-Hill and Reza Abbaschian
2. "Introduction to Materials Science for Engineers" by James F. Shackelford
3. “Solid State Phase Transformations” by Raghavan, PHI

MTPC2006 DEFORMATION BEHAVIOUR OF MATERIALS (3-0-0)

Course Objective: To obtain knowledge of the stress response of materials, load-bearing ability, and elastic and plastic deformation. To obtain insight about different mechanical properties of materials under engineering applications.

Module I (6 Hrs)
Introduction: Elastic, plastic and visco-elastic deformation.
Continuum mechanics: Concepts of stress and strain in 2D and 3D stress and strain tensor, principal stresses and strains and principal axes, mean stress, stress deviator, maximum shear, equilibrium of stresses, yield criteria.

Module II (6 Hrs)
Plastic response of materials: classification of stress-strain curves, stress-strain curves of fcc, bcc and hcp materials.
Plastic deformation of single crystals: Deformation by slip, slip in a perfect lattice, critical resolved shear stress, strain hardening of single crystal.

Module III (6 Hrs)
Lattice Defects: lattice defects
Dislocation Theory: Elements of dislocation theory, movement of dislocation, elastic properties of dislocation, intersection of dislocation, dislocation reactions in different crystal structures, origin and multiplication of dislocations, dislocation pile-ups.

Module IV (6 Hrs)
Plastic deformation of polycrystalline materials: Role of grain boundaries in deformation, strengthening by grain boundaries, yield point phenomenon, strain ageing, strengthening by solutes, precipitates, dispersoids and fibres.
Tension test: Engineering & true stress-strain curves, evaluation of tensile properties, Tensile instability, Effect of strain-rate & temperature on flow properties.

Module V (6 Hrs)
Fracture: Types of fracture in metals, theoretical cohesive strength of metals, Griffth theory of brittle fracture, fracture of single crystals, metallographic aspects of fracture.
Fatigue: Stress cycles, the S-N Curve, Effect of Mean Stress on fatigue, Cyclic Stress-Strain curve, Low and High Cycle fatigue.
Creep and Stress Rupture: Creep Curve, Stress-Rupture Test, structure change during creep, mechanism of creep deformation.

Course Outcome:
CO1: Use simple continuum mechanics and elasticity principles to determine the stresses, strains and displacements in a loaded structure.
CO2: Understand and analyze strain hardening and plastic theory in metals.
CO3: Understand and analyzedislocation theory in metals.
CO4: Understand the basic strengthening mechanisms that can improve the mechanical properties of materials.
CO5: Use fracture mechanics to quantitatively estimate failure criteria and life prediction strategies for both elastic and plastically deforming structures.Understand fatigue and creep failures and how they affect the structural lifetimes of components.

Text Books:
1. Mechanical Metallurgy by G. E. Dieter, McGraw-Hill.
2. Deformation and Fracture Mechanics of Engineering Materials by R.W.

3. Hertzberg, John Wiley.
4. Mechanical Behaviour of Materials by M. A. Meyers and K. K. Chawla
5. Mechanical Behaviour of Materials by T.H. Courtney

MTPC2007 IRON MAKING AND STEEL MAKING (3-0-0)

Course Objective:

1. To understand the various processes used for iron making and the raw material characteristics required
2. To learn about the process of steel making

Module I (6 Hrs)

Raw materials and their properties: Iron ores, Limestones, Agglomerates and Coke. Preparation of ores : Sintering and palletizing, blast furnace burdening and distribution, testing of raw materials for blast furnace, material balance. Design : Blast furnace profile, stove and gas cleaning units; instrumentation, refractory used in blast furnace and stove. Reactions in stack, bosh and hearth; formation of primary slag, bosh slag and hearth slag. Irregularities in blast furnace operation and their remedies.

Module II (6 Hrs)

Process Control: Factors affecting fuel consumption and productivity, Recent developments in Blast furnace operations like, Bell-less top charging system, High top pressure, Humidified & Oxygen enriched blast and Auxiliary fuel injection through tuyers. Alternative routes of iron making: Introduction, Processes of Sponge Iron production; SL/RN, MIDRES, HyL processes. Smelting Reduction Processes; COREX, ROMELT.

Module III (6 Hrs)

Introduction: History of steel making, principles of steel making reactions viz. decarburization desulphurization, dephosphorisation, silicon and manganese reactions. Slag theories: Molecular and ionic theories; interpretation of the above reactions in terms of ionic theory of slags.

L.D. Process: Design of converter and lance; quality of raw materials charged, operation, control of bath and slag composition, chemical reactions involved, termperature and residual bath oxygen control, use of oxygen sensor; some characterstics of L.D blow viz. emulsion formation, slopping, lance height for dephosphorisation and decarburization. Catch Carbon technique.

Module IV (6 Hrs)

Electric arc furnace: Advantages, charging, melting and refining practices for plain carbon and alloy steel; uses of DRI in arc furnace and its effect on performance, water cooled panel and computer control. Combination of blast furnace: EAF Duplex processes of stainless steel making using VOD, AOD and CLU.

Module V (6 Hrs)

Deoxidation of liquid steel: Requirements of deoxidizers, deoxidation practice, stoke's law, use of complex deoxidizers. Includions and their influence on quality of steel. Killed, semi-killed and rimming steel. Secondary refining of steel: Objectives; principles of degrassing different industrial process such as DH, RH, VAD, LF and ESR; limitations and specific applications. Continuous Casting of steel: Advantages; types of machines; mould lubrication and reciprocation. Development in C.C.

Course Outcome:

CO1: Students will understand the preparation, testing, and reactions of raw materials in blast furnace operations and learn to address operational irregularities.

CO2: Students will understand advancements in blast furnace operations and alternative iron-making processes, including smelting reduction and sponge iron production techniques.

CO3: Students will understand the principles and reactions of steel-making processes, slag theories, and operational control in the L.D. process.

CO4: Students will understand the advantages, practices, and processes of electric arc furnace operations, including the use of DRI, water-cooled panels, computer control, and duplex processes like VOD, AOD, and CLU for stainless steel making.

CO5: Students will understand deoxidation, secondary refining processes, and continuous casting

methods to enhance steel quality and industrial applications

Text Books:

1. Ironmaking and Steelmaking Theory and Practice by A. Ghosh and A. Chatterjee, PHI.
2. An Introduction to Modern Iron Making by R.H. Tupkary, V.R. Tupkary, Khanna Publication.
3. Steel Making by A.K. Chakravorty, PHI.
4. Introduction to Modern Steel Making by R.H. Tupkary, Khanna Publishers, New Delhi, 1977.

Reference Books:

1. Anil K. Biswas, Principles of Blast Furnace Iron Making, SBA Publication, 1999.
2. David H. Wakelin (ed.), The Making, Shaping and Treating of Steel (Iron Making Volume), The AISE Steel Foundation, 2004.
3. R. H. Tupkary and V. R. Tupkary, An Introduction to Modern Iron Making, Khanna Publication.
4. A. K. Chakravorty, Steel Making, PHI.

MTPC2204 TRANSPORT PHENOMENA LAB. (0-0-3)

List of experiments

1. To find thermal conductivity of composite wall
2. To find overall heat transfer coefficient in counter flow heat exchanger/parallel flow heat exchanger
3. To verify the flow whether it is laminar or turbulent.
4. To find out the pressure drop (flow through pipes).
5. To determine minimum fluidization velocity and pressure drop
6. To find out the pressure drop when a fluid is flowing through a packed bed
7. To find out the flow rate of fluid flowing inside a pipe by using venturi meter.
8. To find out the flow rate of fluid flowing inside a pipe by using orifice meter
9. To verify the Bernoulli's equation by using Bernoulli's apparatus

Course Outcome:

CO1: Students will learn to determine thermal conductivity, overall heat transfer coefficients in heat exchangers, and verify Bernoulli's equation, enhancing their ability to analyze heat and fluid flow systems.

CO2: Students will develop skills to measure flow rates using venturi and orifice meters, analyze pressure drops in pipes, packed beds, and fluidized beds, and distinguish between laminar and turbulent flow

MTPC2205 PHASE TRANSFORMATION AND HEAT TREATMENT OF METALS LAB. (0-0-3)

List of experiments

1. Annealing treatment of a cold worked steel and comparison of the annealed microstructure with the cold worked structure.
2. Normalizing treatment of steel and comparison of the microstructure with annealed structure.
3. To study the quenched structures of steel – quenched in oil, water and brine solution.
4. To study the quenched and tempered structures of steel –
   (i) low temperature tempering.
   (ii) medium temperature tempering.
   (iii) high temperature tempering.
5. To study the effect of time and temperature on grain size of a metal (grain growth) (iron/ copper).
6. To study the nucleation rate and growth rate of pearlite in eutectoid steel.
7. To determine the hardness of different phases / constituents in multiphase structures using micro hardness tester.
8. Determination of hardenability of steels.
9. Heat treatment of brass alloy.
10. Heat treatment of maraging steel.

Course Outcomes:

CO1: Understand and analyze the effects of various heat treatments on the microstructure and mechanical properties of metals and alloys.
CO2: Evaluate grain growth, phase transformations, and hardenability in steels and non-ferrous alloys.
CO3: Develop skills in using micro-hardness testing and interpreting microstructural changes.
CO4: Develop skills in using micro-hardness testing and interpreting microstructural changes.
CO5: Gain practical knowledge of heat treatment processes for specific alloys like brass and maraging steel.

MTPC2206 DEFORMATION BEHAVIOUR & MECHANICAL TESTING LAB. (0-0-3)

List of Experiments

1. To determine the Vickers Hardness Number of the given samples.
2. To determine the Brinell Hardness Number of the given samples.
3. To determine the Rockwell Hardness of the given samples.
4. To determine the impact strength of the given samples by Charpy and Izod Impact Tests.
5. To determine the tensile strengths of the given materials using a Universal Testing Machine.
6. To determine the compression strength of the given sample.
7. To determine the fatigue strength of the given sample.
8. To determine the drawability of aluminium/steel sheet by Erichsen Cup Test.
9. To study the Ultrasonic Flaw Detector and determine the cracks within a sample.
10. To determine the cracks in a sample using the Magnetic Crack Detector.

Course Outcome:

CO1: Students will learn to evaluate mechanical properties such as hardness, impact strength, tensile strength, and fatigue strength of materials.

CO2: Students will gain expertise in detecting internal and surface defects using Ultrasonic and Magnetic Crack Detection methods.

CO3: Students will understand the drawability and formability of materials through the Erichsen Cup Test.

MTPC2207 MODELING OF PROCESS METALLURGY LAB. (0-0-3)

1. Introduction to terms, properties related to process metallurgy.
2. Generate phase diagrams using Facts age/HSC chemistry software etc.
3. Model and calculation of predominance area diagram using facts age and other software.
4. Construct Eh-pH (Pourbaix) diagram of Fe, Cu, Al, Zn. using facts age and other software.
5. Modelling thermodynamic equilibrium in steel making using Thermo-calc/ facts age etc. software.
6. Analysis of process metallurgy parameters using Design of experiment tools or any other tools.
7. Correlation of metallurgical parameters, in a process by using Minitab software or any other software.
8. To draw a sphere using MATLAB and extend the program to draw FCC and BCC crystal structure
9. Preparation of a model for extracting copper by pyrometallurgical process.
10. Preparation of a model of blast furnace.
11. Preparation of a model of an electric arc furnace or LD furnace.
12. Preparation of a model for cast iron making.
13. Preparation of flow sheets of different metallurgical process.

Course Outcome:

CO1: To acquire a hands-on training on different modelling and simulation techniques.
CO2: To acquire a hands-on experience in applying mathematical modelling technique to process metallurgy.
CO3: To acquire knowledge about various metallurgical process.

PCAC2008 MACHINE LEARNING TECHNIQUES AND APPLICATIONS 3-0-0
OVERALL COURSE OBJECTIVES: Acquire and apply knowledge of machine learning models to solve complex problems across various fields, manage machine learning projects effectively using data science processes, and make informed decisions on technology choices in machine learning system designs.

LEARNING OUTCOMES: On successful completion of the course the students shall be able to:

1. Gain foundational knowledge of various machine learning models such as logistic regression, multilayer perceptrons, and convolutional neural networks.
2. Apply machine learning models to address complex problems in different fields such as medical diagnostics, image recognition, and text prediction.
3. Perform hands-on tasks using PyTorch and other open-source libraries to implement machine-learning algorithms.
4. Identify potential opportunities for implementing machine learning to resolve user problems.
5. Use the data science process to effectively manage and organize machine learning projects.
6. Evaluate and decide on key technology choices in machine learning system design.

COURSE CONTENT:
Module 1: Introduction to Machine Learning [25 Hours]
This course will provide you a foundational understanding of machine learning models (logistic regression, multilayer perceptrons, convolutional neural networks, natural language processing, etc.) as well as demonstrate how these models can solve complex problems in a variety of industries, from medical diagnostics to image recognition to text prediction. In addition, we have designed practice exercises that will give you hands-on experience implementing these data science models on data sets. These practice exercises will teach you how to implement machine learning algorithms with PyTorch, open source libraries used by leading tech companies in the machine learning field (e.g., Google, NVIDIA, CocaCola, eBay, Snapchat, Uber and many more).

Sub-Topic
Simple Introduction to Machine Learning
Basics of Model Learning
Image Analysis with Convolutional Neural Networks
Recurrent Neural Networks for Natural Language Processing
The Transformer Network for Natural Language Processing
Introduction to Reinforcement Learning

Formative Assessments:
4 quizzes and 11 ungraded lab assignments.
Module 2: Managing Machine Learning Projects [18 Hours]
This practical course, part of the AI Product Management Specialization by Duke University's Pratt School of Engineering, provides detailed insights into managing machine learning projects. Walking through each stage of an ML project - right from identifying valid opportunities for ML, to data collection, model building, deployment, and maintenance of production systems - it imparts knowledge of the data science process and its ML applications, and the vital decisions made in ML system design. By the end of the course, participants will be adept at recognising ML application opportunities, applying the data science process to organize ML projects, evaluating crucial technology decisions in ML system design, and leading ML projects from ideation through to production.

Sub-Topic
Identifying Opportunities for Machine Learning
Organizing ML Projects
Data Considerations
ML System Design & Technology Selection
Model Lifecycle Management

Formative Assessments:
5 quizzes and 1 peer-review assignment.

ASSESSMENT:
For summative assessments, Coursera will provide question banks for which exams can be conducted on the Coursera platform or the faculty will create their own assessments.

Note: If a Course or Specialization becomes unavailable prior to the end of the Term, Coursera may replace such Course or Specialization with a reasonable alternative Course or Specialization.

PCAC2009 BIG DATA INTEGRATION AND MANAGEMENT (3-0-0)

OVERALL COURSE OBJECTIVES: The overall course objective is to enable learners to effectively understand and handle big data issues, develop skillsets for processing and integrating big data on Hadoop and Spark platforms, and apply machine learning techniques to construct data-driven models and facilitate decision-making process.

LEARNING OUTCOMES: On successful completion of the course the students shall be able to:

1. Ability to recognize different data elements in various scenarios and explain the necessity for a Big Data Infrastructure Plan and Information System Design.
2. Ability to select suitable data models for specific types of data and apply techniques for handling streaming data.
3. Proficiency in retrieving data from different databases and big data management systems, and identifying when a big data problem needs data integration.
4. Capability to execute basic big data integration and processing on Hadoop and Spark platforms.
5. Ability to design a strategy to leverage data using the steps in the machine learning process and apply machine learning techniques to explore and prepare data for modelling.
6. Proficiency in constructing models that learn from data using open source tools and analyzing big data problems using scalable machine learning algorithms on Spark.

COURSE CONTENT:

Module 1: Big Data Modeling and Management Systems [13 Hours]

This course covers how to collect, store, and organize big data using appropriate management tools. It explores a range of data genres, big data platforms, big data management systems, and analytical tools. Guided, hands-on tutorials provide familiarization with techniques using real-time and semi-structured data examples. Systems and tools covered include AsterixDB, HP Vertica, Impala, Neo4j, Redis, SparkSQL. Key learning outcomes include identifying different data elements, designing a Big Data Infrastructure Plan and Information System, handling streaming data, differentiating between a traditional Database Management System and a Big Data Management System, and designing a big data information system. The course is suitable for those new to data science with completion of the Intro to Big Data recommended. Basic installation skills and virtual machine usage are necessary for hands-on assignments.

Sub-Topic

Designing a Big Data Management System for an Online Game
Introduction to Big Data Modeling and Management
Working With Data Models
Exploring Streaming Sensor Data
DBMS-based and non-DBMS-based Approaches to Big Data

Formative Assessments:

4 graded quizzes and 1 Peer-review assignment.

Module 2: Big Data Integration and Processing [18 Hours]

The course covers the process of identifying, collecting, storing, and organizing big data. It explores various data genres, management tools, big data platforms, management systems, and analytical tools. Through hands-on tutorials, learners will get familiar with real-time and semi-structured data examples. The course discusses various systems and tools including AsterixDB, HP Vertica, Impala, Neo4j, Redis, and SparkSQL. By the end, learners will be able to recognize different data elements, understand why a Big Data Infrastructure Plan is necessary, identify frequent data operations, select suitable data models, handle streaming data, differentiate between traditional and big data management systems, and design a big data information system. It is intended for data science beginners. Prior programming experience is not needed, but the ability to install applications and utilize a virtual machine is essential for hands-on assignments.

Sub-Topic

Big Data Analytics using Spark

Big Data Integration
Learn By Doing: Putting MongoDB and Spark to Work
Processing Big Data
Retrieving Big Data

Formative Assessments:
10 graded quizzes

Module 2: Machine Learning With Big Data [22 Hours]
This course provides an introduction to machine learning techniques used to explore, analyze, and utilize data. It offers insights into various tools and algorithms for creating machine learning models that can learn from data and handle big data problems. After completion, learners will be equipped to devise an approach to leverage data using machine learning processes, apply machine learning techniques for data modeling, recognize the type of machine learning problem to implement suitable techniques, create models with widely available open-source tools, and analyze big data problems using scalable machine learning algorithms on Spark.
Sub-Topic

Data Exploration
Data Preparation
Evaluation of Machine Learning Models
Introduction to Machine Learning with Big Data
Regression, Cluster Analysis, and Association Analysis

Formative Assessments:
11 graded quizzes.

ASSESSMENT:
For summative assessments, Coursera will provide question banks for which exams can be conducted on the Coursera platform or the faculty will create their own assessments.

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PCAC2010 APPLICATION DEVELOPMENT - TOOLS & TECHNOLOGIES (3-0-0)

OVERALL COURSE OBJECTIVES: To develop comprehensive knowledge and skills in Python, AI application development, and interacting with databases, which enables the learner to apply Python to data science tasks, develop AI-driven applications, manage SQL databases, and implement full-stack Django-based solutions.

LEARNING OUTCOMES: On successful completion of the course the students shall be able to:

1. Understand and implement basic and advanced Python concepts, including the use of libraries like Pandas, Numpy & Beautiful Soup.
2. Develop the ability for data collection, manipulation, and web scraping using Python.
3. Apply foundational Python skills to develop Artificial Intelligence (AI) enabled applications with Python and Flask.
4. Employ different Python techniques to develop web applications, write unit tests, and package applications for distribution.
5. Gain a thorough understanding of SQL and how Python interacts with databases using Object-Relational Mapping (ORM) with Django.
6. Implement a Django web application to manage data and gain experience deploying it to the cloud.

COURSE CONTENT:

Module 1: Python for Data Science, AI & Development [27 Hours]

This beginner-friendly, self-paced Python course starts from basics and progresses to programming in Python within a few hours. None prior programming experience needed! The course covers Python basics, different data types, and core components such as List, Tuples, conditions, and branching. It also illustrates how to utilize Python libraries like Pandas, Numpy, and Beautiful Soup, and perform data collection and web scraping tasks using APIs. The learning experience is enriched with hands-on labs using Jupyter Notebooks. On course completion, learners should be able to create basic programs, work with data, and automate real-world tasks using Python. It is an ideal choice for aspiring data scientists, software developers, data engineers, and individuals interested in AI and DevOps roles.

Sub-Topic

APIs, and Data Collection
Python Basics
Python Data Structures
Python Programming Fundamentals
Working with Data in Python

Formative Assessments:

6 graded quizzes.

Module 2: Developing AI Applications with Python and Flask [19 Hours]

This mini course provides hands-on experience in applying basic Python skills to develop Artificial Intelligence (AI) enabled applications. As a developer, learners will undertake various tasks such as developing functions and application logic, exchanging data through Watson AI libraries, writing unit tests, and packaging applications for distribution. The course allows learners to demonstrate their foundational Python skills through the development of web applications and AI-powered solutions. On completion, not only will learners gain confidence in creating AI-enabled applications with Python, Flask, Watson AI libraries, and handling unit tests, but will also add a valuable project to their portfolio.

Sub-Topics

Creating AI Application and Deploy using Flask
Python Coding Practices and Packaging Concepts
Web App Deployment using Flask

Formative Assessments:

1 peer-review assignment and 2 staff graded assignments.

Module 3: Django Application Development with SQL and Databases [14 Hours]

This course, crucial for developers, particularly in Back-End, Full Stack, and DevOps roles, focuses on the fundamentals of relational databases and how to access them from applications. Recognizing that key tasks in application development involve accessing, processing, and presenting data, the course provides insights into foundational database concepts and the basics of SQL. Besides SQL, learners will explore Object-Relational Mapping (ORM), which facilitates the use of Object-Oriented Programming languages, like Python, with databases. The course also assists in acquiring full-stack Django skills through the creation of a Django web app and offers hands-on experience in cloud deployment. Hands-on labs and a final project ensure learners can apply their knowledge and add a valuable asset to their portfolio.

Sub-Topics
Getting Started with SQL & Relational Databases
Consolidate and Deploy Your Django App
Full-stack Django Development
ORM: Bridging the Gap Between the Real World and Relational Model
Formative Assessments:
3 graded quizzes, 1 peer-review assignment and 2 staff graded assignments.

ASSESSMENT:
For summative assessments, Coursera will provide question banks for which exams can be conducted on the Coursera platform or the faculty will create their own assessments.
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PCAC2011 CLOUD INFRASTRUCTURE & APPLICATIONS (3-0-0)

OVERALL COURSE OBJECTIVES: Students will synthesize and apply comprehensive knowledge on distributed and cloud computing concepts, cloud services, infrastructure, data analytics, storage services, machine learning, and real-time streaming technologies, leveraging major service providers to build, manage, and optimize scalable, effective cloud solutions using cutting-edge tools & techniques.

LEARNING OUTCOMES: On successful completion of the course the students shall be able to:

1. Understand and apply key distributed computing concepts for cloud computing including clouds, MapReduce, and NoSQL stores.
2. Utilize modern cloud technologies and the architecture behind the Cloud Systems and Infrastructure, and how virtualization and containers play a role.
3. Grasp how cloud service providers like Amazon, Google, and Microsoft organize their services and offerings.
4. Apply knowledge of cloud middleware technologies such as RPC and REST, JSON and load balancing for cloud-based applications.
5. Comprehend the operational aspects of cloud storage services such as Hive, HDFS, Ceph, cloud object storage systems, and more.
6. Implement data analytics applications on cloud, understand large scale data storage, consensus algorithms, real-time streaming technologies, and machine learning in cloud computing.

COURSE CONTENT:

Module 1: Cloud Computing Concepts: Part 2 [20 Hours]

Cloud computing systems today, whether open-source or used inside companies, are built using a common set of core techniques, algorithms, and design philosophies – all centered around distributed systems. Learn about such fundamental distributed computing "concepts" for cloud computing. Some of these concepts include: clouds, MapReduce, key-value/NoSQL stores, classical distributed algorithms, widely-used distributed algorithms, scalability, trending areas, and much, much more! Know how these systems work from the inside out. Get your hands dirty using these concepts with provided homework exercises. In the programming assignments, implement some of these concepts in template code (programs) provided in the C++ programming language. Prior experience with C++ is required. The course also features interviews with leading researchers and managers, from both industry and academia. This course builds on the material covered in the Cloud Computing Concepts, Part 1 course.

Sub-Topics

Classical Distributed Algorithms Continued
Concurrency and Replication Control
Emerging Paradigms
Classical Systems
Real-Life Behaviors

Formative Assessments:

6 quizzes and 1 coding/lab assignment.

Module 2: Cloud Computing Applications, Part 1: Cloud Systems and Infrastructure [15 Hours]

Welcome to the Cloud Computing Applications course - an ensemble of informative components providing detailed insights on the world of Cloud Computing and Big Data. The course begins with an introduction to cloud computing, its economic foundations, and the concept of big data. It progresses to software-defined architectures, cloud virtualization, and cloud provider offerings. Further focus is given on virtualization and container technologies including Docker, JVM, and Kubernetes. The course also deep dives into cloud offerings like platform-as-a-service, mobile backend-as-a-service, and serverless architectures with a focus on cloud middleware technologies. The topic of Metal-as-a-Service (MaaS) is also covered. The final week focuses on higher-level cloud services, especially cloud storage services, with introductions to Hive, HDFS, and Ceph, cloud object storage systems, virtual hard drives, and archival storage options. The course wraps up with a discussion on Dropbox's cloud solution.

Sub-Topics

Introduction to Cloud Computing
Cloudonomics

Foundations: Containers, Virtual Machine, JVM
MAAS, PAAS, Web Services
Storage: Ceph, SWIFT, HDFS, NAAS, SAN, Zookeeper
Formative Assessments:
4 quizzes.
Module 3: Cloud Computing Applications, Part 2: Big Data and Applications in the Cloud [20 Hours]
The Cloud Computing Applications course provides comprehensive knowledge on Cloud Computing and Big Data. Starting with an overview of cloud computing, its economic underpinnings, and the concept of big data, the course then delves into software-defined architectures, cloud virtualization, and offerings from cloud service providers. Emphasizing virtualization and containers, it includes lectures on Docker, JVM, and Kubernetes. The course explores higher-level cloud offerings like platform-as-a-service, mobile backend-as-a-service, and serverless architectures, along with cloud middleware technologies. The module on Metal-as-a-Service (MaaS) is also included. The final week concentrates on high-level cloud services - particularly cloud storage services introducing Hive, HDFS, Ceph, cloud object storage systems, virtual hard drives, and archival storage options, concluding with a discussion on Dropbox's cloud solution.

Sub-Topics
Spark, Hortonworks, HDFS, CAP
Introduction to Distros
Large Scale Data Storage
Streaming Systems
Big Data Machine Learning Introduction
Graph Processing and Machine Learning
Formative Assessments:
4 quizzes.
ASSESSMENT:
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PCAC2012 INTERNET OF THINGS AND CLOUD (3-0-0)

OVERALL COURSE OBJECTIVES: To provide learners with an in-depth understanding of the evolution of Internet of Things and related technologies, equip them with the skills to utilize advanced technology platforms like DragonBoard™ and AWS, and allow them to apply these skills in developing innovative IoT-enabled applications and systems.

LEARNING OUTCOMES: On successful completion of the course the students shall be able to:

1. Understand, compare, and explain how telephony and media delivery networks operate.
2. Understand circuit switched networks and packet switched networks and their trade-offs.
3. Comprehend key innovations that have transformed the communication, entertainment, and consumer electronics industry.
4. Describe the DragonBoard™ 410c peripherals, I/O expansion capabilities, computing capabilities, and connectivity capabilities.
5. Use Linux terminal for embedded purposes and configure integrated development environment (IDE) for software development.
6. Understand and utilize various AWS cloud services such as EC2, IoT and more, to build and integrate projects that leverage the cloud.

COURSE CONTENT:

Module 1: Internet of Things: How did we get here? [21 Hours]

This course explores the convergence of multiple disciplines that have led to the advent of present-day smartphones and the Internet of Things. The lessons explore the evolution of telephony networks, broadcast networks, and consumer electronics, along with the impact of the internet, multimedia content, smartphones, and apps. It also covers the emerging, interconnected platform: the Internet of Things. Upon completion, learners will understand how peer-to-peer networks differ from broadcast networks, the tradeoffs between circuit-switched and packet-switched networks, and the workings of several key innovations and digital services. The course provides an important grounding for anyone interested in the technological development of the Internet of Things, and further resources for a more in-depth exploration of the topics.

Sub-Topics

Circuit Switched Networks
Computer Telephony
Features and Apps
Future Outlook
Packet Switched Networks
Wireless Technologies

Formative Assessments:

16 quizzes.

Module 2: Internet of Things V2: DragonBoard™ bring up and community ecosystem [21 Hours]

This course is designed for individuals seeking to develop the skills needed to prototype embedded products using advanced technologies. The course utilizes the DragonBoard™ 410c single board computer (SBC) to provide a hardware and software development environment for Internet of Things specialization courses. Ideal for learners interested in using Linux for embedded purposes, pursuing a career in the design and development of Internet of Things products, or those involved in entrepreneurial, innovative, or DIY communities, this course offers both theoretical knowledge and hands-on development practice. Key learning outcomes include understanding the DragonBoard™ 410c peripherals, navigating a Linux terminal, configuring an integrated development environment (IDE) for software development, utilizing Git and GitHub for version control, and creating projects that interface with sensors and actuators through GPIO and Arduino.

Sub-Topics

Advanced Projects and Code
Changing your Operating System (Supplemental / Optional)

DragonBoard Bringup and Ecosystem
Mezzanines and Sensors (Canned Demos w/ software)
Rescuing your Bricked Board (Supplemental / Optional)
Formative Assessments:
5 quizzes and 1 peer-review assignment.

Module 3: Internet of Things V2: Setting up and Using Cloud Services [10 Hours]
This course provides an introduction to Amazon Web Services (AWS) and its significance, enabling learners to make informed design decisions about which services to use. The course covers interfacing with the AWS cloud, developing software for data sending and receiving, and how to structure projects with diverse services. Upon completion, learners will have a clear understanding of the cloud, be able to install and configure the AWS CLI and SDK on a Linux system, utilize various AWS services such as EC2, IoT, etc., build projects heavily leveraging the cloud, and integrate the cloud into embedded systems.

Sub-Topics
Advanced Projects and Code - Deep dive
Systems Architecture

Cloud 101 for Dragonboard 410c
Real projects using AWS Cloud services
Formative Assessments:
3 quizzes and 1 peer-review assignment.

ASSESSMENT:
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PCAC2013 ROBOTICS : MOBILITY & DESIGN (3-0-0)

OVERALL COURSE OBJECTIVES: To develop a comprehensive understanding of robotic mobility and perception, by learning to design efficient robotic bodies, implementing concepts of kinematics and dynamics, developing sensorimotor programs, and utilizing visual and sensory information for manipulation and navigation tasks.

LEARNING OUTCOMES: On successful completion of the course the students shall be able to:

1. Understand how to design robotic bodies and behaviors for efficient and reliable mobility in a dynamic world.
2. Apply the concept of kinematics and dynamics in designing legged machines and robots.
3. Develop sensorimotor programs through simple dynamical abstractions.
4. Comprehend the transformation process of images and videos into 2D representations for efficient grasping and navigation.
5. Identify the calculation of 3D posing of objects to facilitate manipulation tasks.
6. Comprehend visual odometry and landmark-based localization for effective navigation.

COURSE CONTENT:

Module 1: Robotics: Mobility [19 Hours]

How can robots use their motors and sensors to move around in an unstructured environment? You will understand how to design robot bodies and behaviors that recruit limbs and more general appendages to apply physical forces that confer reliable mobility in a complex and dynamic world. We develop an approach to composing simple dynamical abstractions that partially automate the generation of complicated sensorimotor programs. Specific topics that will be covered include: mobility in animals and robots, kinematics and dynamics of legged machines, and design of dynamical behavior via energy landscapes.

Sub-Topics

Anchors: Embodied Behaviors
Behavioral (Templates) & Physical (Bodies)
Composition (Programming Work)

Formative Assessments:

23 quizzes

Module 2: Robotics: Perception [33 Hours]

How can robots perceive the world and their own movements so that they accomplish navigation and manipulation tasks? In this module, we will study how images and videos acquired by cameras mounted on robots are transformed into representations like features and optical flow. Such 2D representations allow us then to extract 3D information about where the camera is and in which direction the robot moves. You will come to understand how grasping objects is facilitated by the computation of 3D posing of objects and navigation can be accomplished by visual odometry and landmark-based localization.

Sub-Topics

Geometry of Image Formation
Glimpse on Vanishing Points
Rotations and Translations
Multi-View Geometry
Pose Estimation
RANSAC: Random Sample Consensus
Projective Transformations

Formative Assessments:

20 quizzes and 4 coding/lab assignments.

ASSESSMENT:

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PCAC2014 IT Fundamentals for Cybersecurity – II (3-0-0)

OVERALL COURSE OBJECTIVES: The objective of this course series is to provide a robust foundation in cybersecurity, emphasizing practical skills in network and database security, the application of generative AI tools in cybersecurity challenges, and detailed methodologies in penetration testing and incident response. This comprehensive approach is designed to prepare students for advanced roles in the cybersecurity field, ensuring they can effectively address and mitigate potential security threats.

LEARNING OUTCOMES: On successful completion of the course the students shall be able to:

1. Gain knowledge of Local Area Networks, TCP/IP, the OSI Framework, and routing basics, and comprehend how networking affects security systems within an organization.
2. Learn about common vulnerabilities in various databases including SQL, Oracle, Mongo, and Couch, and apply knowledge to mitigate risks such as SQL Injection.
3. Apply generative AI tools to combat cyber threats by detecting vulnerabilities and automating the creation of cybersecurity content like playbooks and threat intelligence reports.
4. Develop skills to perform penetration testing using various tools, gather essential data, and understand the phases of testing to improve organizational security.
5. Understand the phases of incident response, from planning and preparation to documentation and recovery, and develop skills in managing and responding to security breaches effectively.
6. Learn key forensic processes and the collection of important digital evidence, enhancing capabilities in analyzing and responding to cybersecurity incidents.

COURSE CONTENT:

Module 1: Network Security & Database Vulnerabilities [18 Hours]

This course gives you the background needed to understand basic network security. You will learn the about Local Area Networks, TCP/IP, the OSI Framework and routing basics. You will learn how networking affects security systems within an organization. You will learn the network components that guard an organization from cybersecurity attacks.

In addition to networking, you will learn about database vulnerabilities and the tools/knowledge needed to research a database vulnerability for a variety of databases including SQL Injection, Oracle, Mongo and Couch.

Sub-Topics

Basics of IP Addressing and the OSI Model
Deep Dive - Injection Vulnerability
Final Project
Introduction to Databases
TCP/IP Framework

Formative Assessments:

4 Graded Quizzes & 1 Peer Review Assignment

Module 2: Generative AI: Boost Your Cybersecurity Career [10 Hours]

This short course provides cybersecurity professionals and enthusiasts with the latest Generative AI tools to address complex cybersecurity challenges.

The course focuses on combating the exploitation of undetected vulnerabilities for which organizations increasingly turn to Artificial Intelligence (AI) and Machine Learning (ML). Generative AI, a transformative technology, emerges as a vital cybersecurity tool, detecting and preventing attacks by identifying and neutralizing unknown vulnerabilities before causing significant harm.

The course explores foundational generative AI principles and their application in real-world cybersecurity, encompassing User and Entity Behavior Analytics (UEBA), threat intelligence, report summarization, playbooks, and its impact on phishing, malware, misinformation, and deepfakes. Additionally, participants learn about potential Natural Language Processing (NLP) attack techniques, like prompt injection, and strategies to mitigate them.

Sub-Topics

Final Project and Exam
Get Started with Gen AI in Cybersecurity

SIEM and SOC Tasks Using Generative AI

Formative Assessments:
3 Staff Graded Assessments

Module 3: Penetration Testing, Incident Response and Forensics [16 Hours]
This course gives you the background needed to gain Cybersecurity skills as part of the Cybersecurity Security Analyst Professional Certificate program.
You will learn about the different phases of penetration testing, how to gather data for your penetration test and popular penetration testing tools. Furthermore, you will learn the phases of an incident response, important documentation to collect, and the components of an incident response policy and team.
Finally, you will learn key steps in the forensic process and important data to collect. This course also gives you a first look at scripting and the importance to a system analyst.
Sub-Topics
Digital Forensics
Incident Response
Introduction to Scripting
Penetration Testing

Formative Assessments:
4 Graded Quizzes
ASSESSMENT:
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