EIGHTH SEMESTER

Sl. No.	Course Category	Subject Code	Subject Title	L	T	P	Contact Hours/ week	Credit	Full Marks
1.	Program Elective-4	PECS 801/1	Distributed Systems	3	0	0	3	3	100
		PECS 801/2	Mobile Computing						
		PECS 801/3	Big Data Analytics						
2.	Program Elective-5	PECS 802/1	Pattern Recognition	2	0	0	2	2	100
		PECS 802/2	Natural Language Processing						
		PECS 802/3	Android Operating System						
3.	Open Elective-1	OE 803	Refer Annexure 3	3	0	0	3	3	100
4.	Open Elective-2	OE 804	Refer Annexure 4	2	0	0	2	2	100
5.	Project - 3	PRCS 805	Project Work Final	0	0	12	12	6	200
6.	Seminar - 2	SECS 806	Seminar on Contemporary Engineering Topics - II	0	0	2	2	1	100
7.	Online Course	SWCS 807	SWAYAM Courses[#]	0	0	0	0	1	100
Total :				10	0	14	24	18	800

Distributed Systems

Course Code	PE CS 801/1
Course Title	Distributed Systems
Number of Credits	3 (L: 3, T: 0, P: 0)
Prerequisites	Database Management Systems
Course Category	Program Elective-4
Number of classes	36 hours

Course Outcome:

After completing this course, the student should be able to-

CO Number	CO Description	K-level
CO-1	Explain the trends in distributed systems	K2
CO-2	Design distributed systems.	K4
CO-3	Apply remote method invocation and objects.	K3
CO-4	Illustrate the reliability issues of distributed systems.	K2

Course Content:

Module 1: Introduction (8hours)

Distributed data processing; what is a DDBS; Advantages and disadvantages of DDBS; Problem areas; Overview of database and computer network concepts
DISTRIBUTED DATABASE MANAGEMENT SYSTEM ARCHITECTURE
Transparencies in a distributed DBMS; Distributed DBMS architecture; Global directory issues .

Module 2: Design (10 hours)

DISTRIBUTED DATABASE DESIGN
Alternative design strategies; Distributed design issues; Fragmentation; Data allocation **SEMANTICS DATA CONTROL**
View management; Data security; Semantic Integrity Control QUERY
PROCESSING ISSUES
Objectives of query processing; Characterization of query processors; Layers of query processing; Query decomposition; Localization of distributed data .

Module 3: **(10hours)**

DISTRIBUTED QUERY OPTIMIZATION
Factors governing query optimization; Centralized query optimization; Ordering of fragment queries; Distributed query optimization algorithms
TRANSACTION MANAGEMENT
The transaction concept; Goals of transaction management; Characteristics of transactions; Taxonomy of transaction models
CONCURRENCY CONTROL
Concurrency control in centralized database systems; Concurrency control in DDBSs; Distributed concurrency control algorithms; Deadlock management

Module 4: **(8 hours)**

Reliability issues in DDBSs; Types of failures; Reliability techniques; Commit protocols; Recovery protocols Algorithm.
PARALLEL DATABASE SYSTEMS
Parallel architectures; parallel query processing.
ADVANCED TOPICS
Mobile Databases, Distributed Object Management, Multi-databases

References / Suggested Learning Resources:

1. Principles of Distributed Database Systems, M.T. Ozsu and PValduriez, Prentice-Hall, 1991.
2. Distributed Database Systems, D. Bell and J. Grimson, Addison- Wesley, 1992.

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Mobile Computing

Course Code	PE CS 801/2
Course Title	Mobile Computing
Number of Credits	3 (L: 3, T: 0, P: 0)
Prerequisites	--
Course Category	Program Core (PC)
Number of classes	36 hours

Course Outcome:

CO Number	CO Description	K-level
CO-1	Explain Mobile Communication and next generation mobile computing system	K2
CO-2	Analyze IP and TCP layers of Mobile Communication.	K3
CO-3	Explain network and transport layers of Mobile Communication.	K2
CO-4	Analyze various protocols of all layers for mobile and ad hoc wireless communication networks.	K3

Course Content:

Module 1 **(8 Hours)**

Basic history of Mobile Computing Architecture for mobile computing, Three tier architecture, design considerations for mobile computing, mobile computing through internet, Wireless network architecture, Applications, Security, Concerns and Standards, Benefits, Future. Evolution of mobile computing.

Module 2 **(12 Hours)**

Overview of Wireless n/w. and Technologies: Introduction, Different generations. Introduction to 1G, 2G, 3G and 4G, Bluetooth, Radio frequency identification(Rfid),Wireless Broadband, Mobile IP: Introduction, Advertisement, Registration, TCP connections, two level addressing, abstract mobility management model, performance issue, routing in mobile host, Adhoc networks, Mobile transport layer: Indirect TCP, Snooping TCP, Mobile TCP, Time out freezing, Selective retransmission, transaction oriented TCP,IPv6 Wireless network topologies, Cell fundamentals and topologies, Global system for mobile communication, Global system for mobile communication, GSM architecture, GSM entities, call routing in GSM,PLMN interface, GSM addresses and identifiers, network aspects in GSM,GSM frequency allocation, authentication and security, Short message services, Mobile computing over SMS,SMS, value added services through SMS,accessing the SMS bearer, Security in wireless networks.

Module 3 **(6 Hours)**

General packet radio service (GPRS): GPRS and packet data network, GPRS network architecture, GPRS network operation, data services in GPRS, Applications of GPRS, Billing and charging in GPRS.

Module 4: **(10 Hours)**

Wireless Application Protocol(WAP): WAP,MMS,GPRS application CDMA and 3G Spread-spectrum Technology, CDMA versus GSM, Wireless data, third generation networks, applications in 3G Wireless LAN, Wireless LAN advantages,IEEE802.11 standards ,Wireless LAN architecture, Mobility in Wireless LAN, Deploying Wireless LAN, Deploying Wireless LAN, Mobile ad hoc networks and sensor networks, wireless LAN security, WiFi v/s 3G Voice over Internet protocol and convergence, Voice over IP,H.323 framework for voice over IP,SIP, comparison between H.323 ad SIP, Real time protocols, convergence technologies, call routing, call routing, voice over IP applications, IMS, Mobile VoIP, 13 30 Security issues in mobile Information security, security techniques and algorithms, security framework for mobile environment.

Suggested books:

1. Mobile Computing,Raj Kamal by Oxford
2. Wireless Communications & Networks, Second Edition,William Stallings by Pearson
3. Mobile Computing Theory and Practice-Kumkum Garg-Pearson
4. TCP/IP Protocol Suite by Behrouz A Forouzan, Third Edition,TMH

Suggested reference books:

1. Mobile Computing Technology, Applications and service creation, Asoke K Telukder, Roopa R Yavagal by TMH.
2. V.K.Garg, J.E.Wilkes, “Principle and Application of GSM”, Pearson Education, 5th edition, 2008.
3. V.K.Garg, “IS-95 CDMA & CDMA 2000”, Pearson Education, 4th edition, 2009.
4. T.S.Rappaport, “Wireless Communications Principles and Practice”, 2nd edition, PHI,2002.
5. William C.Y.Lee, “Mobile Cellular Telecommunications Analog and Digital Systems”, 2nd edition, TMH, 1995.
6. Asha Mehrotra, “A GSM system Engineering” Artech House Publishers Bosten, London,1997

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Big Data Analytics

Course Code	PE CS 801/3
Course Title	Big Data Analytics
Number of Credits	3 (L: 3, T: 0, P: 0)
Prerequisites	Data Mining
Course Category	Program Elective (PE)
Number of classes	36 hours

Course Outcome:

After completion of the course, students will be able to:

CO Number	CO Description	K-level
CO-1	Explain big data and use cases from selected business domains.	K2
CO-2	Explain NoSQL big data management.	K3
CO-3	Configure, and run Hadoop and HDFS and perform map-reduce analytics using Hadoop	K3
CO-4	Utilize Hadoop related tools such as Cassandra, Pig, and Hive for big data analytics	K2

Module 1: Introduction (8)

Types of Digital Data-Characteristics of Data – Evolution of Big Data - Definition of Big Data - Challenges with Big Data - 3Vs of Big Data - Non Definitional traits of Big Data - Business Intelligence vs. Big Data - Data warehouse and Hadoop environment - Coexistence. Introduction to Big Data tools like Hadoop, Spark, Impala etc., Data ETL process, Identify gaps in the data and follow-up for decision making.
Map Reduce: Mapper – Reducer – Combiner – Partitioner – Searching – Sorting – Compression.

Module 2: Big Data Analytics (8)
Big Data Analytics: Classification of analytics - Data Science - Terminologies in Big Data - CAP Theorem - BASE Concept. Run descriptive to understand the nature of the available data, collate all the data sources to suffice business requirement, Run descriptive statistics for all the variables and observer the data ranges, Outlier detection and elimination. Hypothesis testing and determining the multiple analytical methodologies, Train Model on 2/3 sample data using various Statistical/Machine learning algorithms, Test model on 1/3 sample for prediction etc.

Module 3: No SQL databases (10)

NoSQL: Types of Databases – Advantages – NewSQL - SQL vs. NOSQL vs NewSQL.
Mongo DB: Introduction – Features - Data types - Mongo DB Query language - CRUD operations – Arrays - Functions: Count – Sort – Limit – Skip – Aggregate - Map Reduce. Cursors – Indexes - Mongo Import – Mongo Export.
Cassandra: Introduction – Features - Data types – CQLSH - Key spaces - CRUD operations – Collections – Counter – TTL - Alter commands - Import and Export - Querying System tables.

Module 4: Hadoop Ecosystems (10)
Hive – Architecture - data type - File format – HQL – SerDe - User defined functions
Pig: Features – Anatomy - Pig on Hadoop - Pig Philosophy - Pig Latin overview - Data types - Running pig - Execution modes of Pig - HDFS commands - Relational operators - Eval Functions - Complex data type - Piggy Bank - User defined Functions - Parameter substitution - Diagnostic operator.
Jasper Report: Introduction - Connecting to Mongo DB - Connecting to Cassandra.
Hadoop 2 (YARN): Architecture - Interacting with Hadoop Eco systems.

Data Visualization: Prepare the data for Visualization, Use tools like Tableau, Qlick View and D3, Draw insights out of Visualization tool

References / Suggested Learning Resources:

1. Seema Acharya, Subhashini Chellappan, “Big Data and Analytics”, Wiley Publication, 2015.
2. Judith Hurwitz, Alan Nugent, Dr. Fern Halper, Marcia Kaufman, “Big Data for Dummies”, John Wiley & Sons, Inc., 2013.
3. Tom White, “Hadoop: The Definitive Guide”, O’Reilly Publications, 2011.
4. Kyle Banker, “Mongo DB in Action”, Manning Publications Company, 2012.
5. Russell Bradberry, Eric Blow, “Practical Cassandra A developers Approach“, Pearson Education, 2014.

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Pattern Recognition

Course Code	PE CS 802/1
Course Title	Pattern Recognition
Number of Credits	3 (L: 3, T: 0, P: 0)
Prerequisites	Soft Computing
Course Category	Program Elective-4
Number of classes	26 hours

Course Outcome:

After completing this course, the student should be able to-

CO Number	CO Description	K-level
CO-1	Explain supervised and unsupervised pattern classifiers	K2
CO-2	Classify the data and identify the patterns	K3
CO-3	Apply different feature extraction techniques.	K3
CO-4	Utilize Hidden Markov model and SVM in pattern recognition.	K3

Course Content:

Module 1: Pattern Classifier (6 hours)

Overview of Pattern recognition – Discriminant functions – Supervised learning – Parametric estimation – Maximum Likelihood Estimation – Bayesian parameter Estimation – Problems with Bayes approach– Pattern classification by distance functions – Minimum distance pattern classifier- Fisher Linear Discriminant.

Module 2: Classification and Clustering (8 hours)

Classification: Bayes decision rule, Error probability, Error rate, Minimum distance classifier, Mahala Nobis distance; K-NN Classifier, Linear discriminant functions and Non-linear decision boundaries.
Clustering for unsupervised learning and classification–Clustering concept – C Means algorithm – Hierarchical clustering – Graph theoretic approach to pattern Clustering – Validity of Clusters
Clustering: Different distance functions and similarity measures.

Module 3: Feature Extraction and Structural Pattern Recognition (6 hours)

Principle component analysis, independent component analysis, Linear discriminant analysis, Feature selection through functional approximation.

Feature selection: Problem statement and Uses, Probabilistic separability-based criterion functions, interclass distance-based criterion functions, Branch and bound algorithm, sequential forward/backward selection algorithms.

Module 4: Hidden Markov Models and Support Vector Machine (6 hours)

State Machines – Hidden Markov Models – Training – Classification – Support vector Machine – Feature Selection-obtaining the optimal hyperplane.

References / Suggested Learning Resources:

1. Andrew Webb, "Statistical Pattern Recognition", Arnold publishers, London,1999
2. C.M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
3. M. Narasimha Murthy and V. Susheela Devi, "Pattern Recognition", Springer 2011.
4. Menahem Friedman, Abraham Kandel, "Introduction to Pattern RecognitionStatistical, Structural, Neural and Fuzzy Logic Approaches", World Scientificpublishing Co. Ltd, 2000.
5. Robert J.Schalkoff, "Pattern Recognition Statistical, Structural and NeuralApproaches", John Wiley & Sons Inc., New York, 1992.
6. R.O. Duda, P.E.Hart and D.G.Stork, "Pattern Classification", John Wiley, 2001
7. S.Theodoridis and K.Koutroumbas, "Pattern Recognition", 4th Ed., Academic Press, 2009
8. R.O. Duda, P.E.Hart and D.G.Stork, Pattern Classification,John Wiley, 2002.
9. C.M. Bishop, Neural Networks and Pattern Recognition,Oxford University Press(Indian Edition), 2003.

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Natural Language Processing

Course Code	PE CS 802/2
Course Title	Natural Language Processing
Number of Credits	02 (L: 2, T: 0, P: 0)
Prerequisites	Nil
Course Category	Program Elective-5
Number of classes	26 hours

Course Outcome:

After completion of the course, students will be able to:

CO Number	CO Description	K-level
CO-1	Explain the various challenges of NLP.	K2
CO-2	Implement a parser by providing suitable grammar and words	K3
CO-3	Perform syntax and semantic analysis using language analysis tools.	K4
CO-4	Design and evaluate the NLP applications.	K3

Course Content:

Module 1: Overview and Language Modeling (6)
Overview: Origins and challenges of NLP – Language and Grammar – Processing Indian Languages – NLP Applications: Machine Translation – Information Extraction. Language Modeling: Introduction – Various Grammar-Based Language Models – Statistical Language Model

Module 2: Part-of-Speech Tagging and Context-Free Grammars (7)
English Word classes – Tag sets for English – Part-of-Speech Tagging – Rule based Part-of-Speech Tagging – Stochastic Part-of-Speech Tagging – Transformation-Based Tagging. Stemming – Context-Free Grammars for English: Constituency – Context Free Rules and Trees – Sentence Level Constructions – The Noun Phrase - Coordination – Agreement – The Verb Phase and Sub categorization – Auxiliaries – Spoken Language Syntax – Grammars Equivalence and Normal Form–Finite-State and Context-Free Grammars – Grammars and Human Processing

Module 3: Parsing & Semantics (8)
Parsing and Advanced Features: Parsing as Search – A Basic Top-Down Parser – Problems with the Basic Top-Down Parser – The Early Algorithm – Finite-State Parsing Methods. Features and Unification: Feature Structures – Unification of Feature Structures – Features Structures in the Grammar – Implementing Unification – Parsing with Unification Constraints – Types and Inheritance.
Semantics Analysis and Lexical Semantics: Semantic Representing Meaning – Meaning Structure of Language – First Order Predicate Calculus – Semantic Analysis: Syntax-Driven Semantic

Analysis – Attachments for a Fragment of English – Integrating Semantic Analysis into the Early Parser – Idioms and Compositionality – Robust Semantic Analysis – Lexical Semantics: Relational among Lexemes and their Senses – Word Net: A database of Lexical Relations – The Internal Structure of Words.

Module 4: Evaluation Metrics & Applications of NLP (5)

Manual Evaluation – Fluency and Adequacy – Other Evaluation Criteria – Automatic Evaluation – Precision and Recall – F-Measure – Word Error Rate – Bilingual Evaluation Understudy – METEOR – Multiple Reference Translations – Pearson's Correlation Coefficient – Hypothesis Testing – Pair wise comparison – Task oriented Evaluation.

Applications of NLP: NL Interfaces, Text Summarization, Sentiment Analysis, Machine Translation, Question answering. Recent Trends in NLP

References / Suggested Learning Resources:

1. Jurafsky, Daniel, and James H. Martin, "Speech and Language Processing: An Introduction to Natural Language Processing, Speech Recognition, and Computational Linguistics", Prentice Hall, 2000.
2. Christopher D. Manning and Hinrich Schütze, "Foundations of Statistical Natural Language Processing". Cambridge, MIT Press, 1999.
3. James Allen, "Natural Language Understanding", Benjamin/Cummings, 2ed, 1995.
4. Eugene Charniak, "Statistical Language Learning", MIT Press, 1996.
5. Martin Atkinson, David Britain, Harald Clahsen, Andrew Redford, "Linguistics", Cambridge University Press, 1999.
6. P. Lieberman, "Toward an evolutionary biology of language", Harvard University Press, 2006.
7. Philipp Koehn, “Statistical Machine Translation”, 1st Edition, Cambridge University Press, January 2010.
8. Tanveer Siddiqui, U.S. Tiwary, “Natural Language Processing and Information Retrieval”, 3rd Edition, Oxford University Press
9. Nitin Indurkhya, Fred J. Damerau, “Handbook of Natural Language Processing”, 2ed, CRC Press, 2010.

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Android Operating System

Course Code	PE CS 802/3
Course Title	Android Operating System
Number of Credits	02 (L: 2,T:0,P:0)
Prerequisites	ES 204 and PECS 701(Kotlin Programming)
Course Category	Program Elective(PE)
Number of classes	26 hours

Course Outcome:

After completion of the course, students will be able to:

CO Number	CO Description	K-level
CO-1	Explain the development tools and major components of Android API.	K2
CO-2	Utilize the user interface properties to develop the structure.	K3
CO-3	Demonstrate the use of multimedia in Android.	K3
CO-4	Analyze the networking and touch event properties in Android.	K4

Course Content:

Module 1: Introduction to Android OS (6)

Android Software Stack, Activities and Applications, Android using Kotlin, Activity Life Cycles, Activity Stacks, Activity States, Resources, Android OS vs. IOS.

Module 2: User Interfaces (8)

Views, Layouts, Android Widgets, UI XML Specifications, Explicit Intents, Implicit Intents, Event Broadcasting with Intents, Event Reception with Broadcast Receivers, Adapters and Data Binding.

Module 3: Multimedia (7)

Audio, Video, Camera, Playing Audio and Video, Recording Audio and Video, Using the Camera to Take and Process Pictures

Module 4: Networking& Touchscreen (6)

Networking Internet Access, HTML and XML Parsing, Wi-Fi, Capturing Touch Events, Touchscreen Gesture Recognition.

References / Suggested Learning Resources:

1. Android Development with Kotlin, by Marcin Moskala and Igor Wojda, Packt Publishing Limited.
2. Rito Meier. "Professional Android Application Development." Wiley Publishing, Inc.
3. Sayed Hashimi, Satya Komatineni, Dave MacLean. "Pro Android 2." APRESS.
4. Mark Murphy. "Beginning Android 2." APRESS.
5. Carmen Delessio, Lauren Darcey ”Android Application Development” Pearson
6. J.F. DiMarzio “Android a programming guide” TMH

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Project Work Final

Course Code	PR CS 805
Course Title	Project Work Final
Number of Credits	6 (L: 0, T: 0, P: 12)
Prerequisites	Nil
Course Category	Project (PR)
Number of classes	130 hours

Course Outcome:-

After completion of the course, students will be able to:

CO Number	CO Description	K-level
CO-1	Demonstrate a sound technical knowledge of their selected project topic	K2
CO-2	Develop the skill of working in a Team	K3
CO-3	Design engineering solutions to complex problems utilizing a systematic approach	K6
CO-4	Design the solution of an engineering project involving latest tools and techniques	K6
CO-5	Develop the skill of effective communication with engineers and the community at large in written an oral forms	K3
CO-6	Demonstrate the knowledge, skills and attitudes of a professional engineer	K2

Course Content:-

The project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The course should have the following-

1) Develop sound knowledge about the domain of the project work.
2) Perform detailed study about various components of a project.
3) Learn to be an important member of a team for successful execution of a project work.
4) Study about methodologies and professional way of documentation and communication related to project work.
5) Develop idea about problem formulation, finding the solution of a complex engineering problem.
6) Develop project report as per the suggested format to communicate the findings of the project work.
7) Acquire the skill of effective oral communication to the fellow engineers and people in the society at large.
8) Develop knowledge of how to organize, scope, plan, do and act within a project thesis.
9) Familiarity with specific tools (i.e. hardware equipment and software) relevant to the project selected.

10) Demonstrate the implementation of a project work.

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Seminar on Contemporary Engineering Topics – II

Course Code	SE CS 806
Course Title	Seminar on Contemporary Engineering Topics – II
Number of Credits	1 (L: 0, T: 0, P: 2)
Prerequisites	Nil
Course Category	Seminar (SE)
Number of classes	24 hours

Course Outcome:-

After completion of the course, students will be able to:

CO Number	CO Description	K-level
CO-1	Identify contemporary topics in respective branch of engineering	K3
CO-2	Survey literature to understand insight of the selected topic	K4
CO-3	Develop report writing and presentation making skill	K3
CO-4	Present the topic so prepared among audience using suitable aid	K3

Course Content:-

Each student shall

1) Identify a topic of current relevance in his/her branch of engineering,
2) Get approval of the faculty concerned/HOD,
3) Collect sufficient literature on the selected topic, study it thoroughly (literature survey),
4) Prepare their own report and presentation slides and
5) Present in the class among fellow students and faculty members.

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SWAYAM Courses

Course Code	SW CS 807
Course Title	SWAYAM Courses
Number of Credits	1 (L: 0, T: 0, P: 0)
Prerequisites	Nil
Course Category	Online Course (SW)
Number of classes	-

Courses Outcome:-

After completion of the courses, students will be able to:

CO Number	CO Description	K-level
CO-1	Make use of digital learning platform to enhance knowledge and skill beyond the prescribed curriculum structure	K3
CO-2	Take part in proctored examination system to prepare oneself for similar future challenges	K4
CO-3	Utilize the opportunity to learn from best faculty in the countryfor professional development	K3
CO-4	Develop the skill of lifelong self-learning and become future ready	K3

Courses Content:-

SWAYAM (Study Webs of Active-learning for Young Aspiring Minds); India Chapter of Massive Open Online Courses. SWAYAM is an indigenous developed IT platform, initiated by Government of India, which is instrumental for self-actualization providing opportunities for a life-long learning. Learner can choose from hundreds of courses, virtually every course that is taught at the university/college/school level and these shall be offered by best of the teachers in India and elsewhere. Student having registered a course, having submitting the Assignments as per requirements of the course, shall at the end of each course, be assessed through a proctored examination. A student having successfully completed the course shall get a Certificate.

Each student has to undergo and qualify at least two relevant SWAYAM or equivalent courses (to be certified by concerned HOD) with certification during the entire course of B. Tech. program. The Head of the departments will approve the relevancy of a SWAYAM or equivalent course for respective branch of engineering.

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PROGRAM OUTCOMES (POs) AS PER NATIONAL BOARD OF ACCREDITATION (NBA)

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.