B. Tech with

HONORS

in

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Academic Regulations, Course Structure and Syllabus

Effective from 2023-24 admitted batches

Offered by

Department of Computer Science and Engineering

KSRM College of Engineering (A) – Kadapa

(Approved by AICTE, Accredited by NAAC with A+ Grade and NBA and Affiliated to JNTUA, Anantapuramu)

ELIGIBILITY / REGISTRATION / AWARD OF HONORS

The objective of introducing B.Tech. (Hons.) is to facilitate the students to choose additionally the specialized courses of their choice and build their competence in a specialized area in the UG level. The program is a best choice for academically excellent students having good academic record and interest towards higher studies and research.

i) Honors is introduced in the curriculum of all B. Tech. programs offering a major degree and is applicable to all B.Tech (Regular and Lateral Entry) students admitted in Engineering & Technology.

ii) Those students with **at least 7.0 CGPA without any course backlogs up to III Semester in the major degree are only eligible to register for Honor degree**.

iii) A student shall earn **additional 18 credits for award of Honors** from same branch / department / discipline registered for major degree. This is in addition to 163 credits by a regular student and 123 Credits by a Lateral Entry student for the award of Major degree.

iv) A student is permitted to register for Honors in IV Semester after the results of III Semester are declared. Students shall register and pass in all the courses prescribed and being offered from V semester under the respective Honor degree.

v) Students have to attend classwork for courses under Honor degree beyond regular academic hours meant for major degree. Students can also undergo the courses under Honor through any proctored online platforms with the prior approval of the BoS Chairman and the HoD of the respective department offering Honor degree.

vi) The attendance for the registered courses under Honors and regular courses offered for Major degree in a Semester will be considered separately.

vii) A student shall have an aggregate of 75% attendance in all courses registered under Honors in that particular semester to become eligible for attending Semester-End examinations.

viii) The registration for the Honor will be cancelled, if the student is detained due to lack of attendance in Major,

ix) The registration for the Honor will be cancelled, if the student fails in any course of either Honor / Major in any semester from V to VIII Semester.

x) A student registered for Honors shall pass in all subjects that constitute the requirement for the Honors degree program. No class/division (i.e., second class, first class and distinction, etc.) will be awarded for Honors degree program.

xi) A separate grade sheet will be issued for the Honor degree courses semester-wise.

xii) If a student drops or is terminated from the Honors program, the additional credits so far earned cannot be converted into open or core electives; they will remain extra.

xiii) The Honors will be mentioned in the degree certificate as Bachelor of Technology (Honors) in XYZ. For example, B.Tech. (Honors) in Mechanical

Engineering.

xiv) There shall be a minimum enrolment of 20% OR 20 enrollments from the list of eligible students to offer Honors program.

xv) There is no fee for registration of courses for Honors program offered.

xvi) A student can register for either Minor / Honor but not both.

xvii) Student shall submit an application for either Minor / Honor at least one week before the commencement of the V Semester.

HONORS PROGRAMS OFFERED

Offering Department	Title	Who can Register
Civil Engineering	Civil Engineering	B.Tech. CE
	Tunnel Engineering	
	Interior Design	
Mechanical Engineering	Mechanical Engineering	B.Tech. ME
Electrical and Electronics Engineering	Electric Vehicles	B.Tech. EEE
Electronics and Communication Engineering	VLSI	B.Tech. ECE
	Embedded Systems and IoT	
Computer Science and Engineering	Computer Science and Engineering	B.Tech. CSE, B.Tech. AIML, B.Tech. CSE(DS), B.Tech. CSE(AIML)
	Artificial Intelligence and Machine Learning	
	Data Science	
	CSE-Artificial Intelligence and Machine Learning	

COURSE STRUCTURE

for

HONORS

in

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

S.No	COURSE CODE	COURSE TITLE	Semester Offered	L	T	P	IM	EM	CR
1	2339571H	Advanced Algorithms for AI and ML	V	3	0	0	30	70	3
2	2339572H	AI and ML Security, Fairness, and Governance	V	3	0	0	30	70	3
3	2339671H	Reinforcement Learning and Autonomous Systems	VI	3	0	0	30	70	3
4	2339672H	Deep Learning and Neural Network Architectures	VI	3	0	0	30	70	3
5	2339771H	AI-Driven Software Engineering and DevOps	VII	3	0	0	30	70	3
6	2339772H	Applied Project Work	VII	0	0	6	60	140	3
Total				**15**	**0**	**6**	**210**	**490**	**18**

		L	T	P	C
2339571H	**HONORS IN ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING ADVANCED ALGORITHMS FOR AI AND ML (AIML)**	**3**	**0**	**0**	**3**

Pre-Requisites: Advanced Data Structures and Algorithm analysis, Machine Learning, Deep Leaning, Graph Neural Networks

Course Outcomes:

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

CO1. Analyze and apply classical algorithmic techniques including divide and conquer, dynamic programming, approximation, and randomized algorithms in the context of AI/ML.

CO2. Implement advanced graph algorithms for shortest paths, flows, and community detection, and apply them to AI problems like NLP and recommender systems.

CO3. Apply convex and non-convex optimization strategies, gradient-based learning, and regularization techniques to train and tune AI/ML models effectively.

CO4. Use evolutionary, swarm intelligence, and reinforcement learning-based metaheuristic methods for neural architecture search and complex optimization tasks in AI.

CO5. Evaluate and design scalable algorithmic solutions with fairness and interpretability for AI/ML applications, referencing case studies like AlphaGo, GPT, and AutoML systems.

SYLLABUS:

UNIT - I: FOUNDATIONS OF ADVANCED ALGORITHMIC TECHNIQUES (11 Periods)

Review of Time and Space Complexity, Divide and Conquer, Dynamic Programming, and Greedy Algorithms, Recurrence Relations and Master Theorem, Approximation Algorithms: Vertex Cover, TSP, Set Cover, Randomized Algorithms: Monte Carlo and Las Vegas Types, Probabilistic Analysis and Tail Bounds, Applications in ML Preprocessing and Feature Selection

UNIT - II: GRAPH ALGORITHMS AND AI APPLICATIONS (09 Periods)

Graph Representations and Traversal Algorithms, Shortest Path: Dijkstra‘s, Bellman-Ford, Floyd- Warshall, Minimum Spanning Trees: Kruskal and Prim, Network Flows and Max Flow-Min Cut Theorem, Graph-Based Semi-Supervised Learning, PageRank, Centrality, and Community Detection, Applications in NLP, Vision, and Recommender Systems

UNIT - III: OPTIMIZATION IN AI/ML (10 Periods)

Convex and Non-Convex Optimization, Gradient Descent Variants: SGD, Momentum, Adam, Convergence Analysis and Learning Rates, Duality and Lagrange Multipliers,

Regularization: L1, L2, ElasticNet, Hyperparameter Optimization: Grid, Random, Bayesian, Constrained Optimization in SVMs and Deep Learning

UNIT - IV: EVOLUTIONARY & METAHEURISTIC ALGORITHMS (09 Periods)

Genetic Algorithms and Evolutionary Strategies, Swarm Intelligence: PSO, Ant Colony Optimization, Simulated Annealing and Tabu Search, Multi-objective Optimization, Reinforcement Learning and Policy Gradient Methods, Neuroevolution: Evolving Neural Networks, Use Cases in Feature Engineering and Neural Architecture Search (NAS)

UNIT - V: ADVANCED TOPICS AND CASE STUDIES (08 Periods)

Online Learning and Regret Minimization, Bandit Algorithms: Multi-Armed Bandits, Thompson Sampling, Large-Scale Algorithms: MapReduce, Apache Spark MLlib, Algorithmic Fairness, Interpretability, and Ethics in AI, Case Studies: AlphaGo, GPT, BERT, Recommendation Engines, Research Trends in Algorithmic ML and AutoML, Capstone Problem Solving using Hybrid Algorithms.

Total Periods: 45

TEXT BOOKS:

T1. Introduction to Algorithms, Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein (MIT Press)
T2. Algorithms for Machine Learning, Giuseppe Bonaccorso, Packt Publishing
T3. Convex Optimization, Stephen Boyd and Lieven Vandenberghe, Cambridge University Press
T4. Reinforcement Learning: An Introduction, Richard S. Sutton and Andrew G. Barto

REFERENCE BOOKS:

R1. Machine Learning: A Probabilistic Perspective, Kevin P. Murphy
R2. The Elements of Statistical Learning, Trevor Hastie, Robert Tibshirani, Jerome Friedman
R3. Evolutionary Computation, Kenneth A. De Jong
R4. Handbook of Approximation Algorithms and Metaheuristics, Teofilo F. Gonzalez

ONLINE COURSES:

1. Coursera – Advanced Algorithms and Complexity (UC San Diego)
2. edX – Algorithmic Design and Techniques (UC San Diego)
3. MIT OpenCourseWare – Advanced Algorithms
4. Udemy – Optimization Algorithms in Machine Learning
5. Stanford Online – Convex Optimization

		L	T	P	C
2339572H	**HONORS IN ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING AI AND ML SECURITY, FAIRNESS, AND GOVERNANCE (AIML)**	**3**	**0**	**0**	**3**

Pre-Requisites: Probability and Statistics, Artificial Intelligence, Machine Learning, Deep Learning.

Course Outcomes:

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

CO1. Analyze the security threats and vulnerabilities in AI and ML pipelines.
CO2. Evaluate fairness and bias issues in machine learning models and datasets.
CO3. Apply techniques to ensure explainability, interpretability, and trustworthiness of AI models.
CO4. Assess ethical, legal, and social implications of deploying AI systems.
CO5. Formulate strategies for AI governance using global frameworks, policies, and standards.

SYLLABUS:

UNIT - I: INTRODUCTION TO AI/ML SECURITY (09 Periods)

AI/ML System Overview and Threat Landscape, Adversarial Attacks in Machine Learning, Data Poisoning and Model Inversion Attacks, Model Stealing and Evasion Techniques, Defenses: Adversarial Training, Robust Optimization, Security by Design in ML Systems

UNIT - II: FAIRNESS IN MACHINE LEARNING (09 Periods)

Understanding Bias: Historical, Measurement, and Algorithmic, Fairness Metrics: Equal Opportunity, Demographic Parity, Equalized Odds, Dataset Pre-processing Techniques, In-processing and Post- processing Fairness Interventions, Auditing Models for Fairness, Case Studies on Biased AI Systems

UNIT - III: EXPLAINABILITY AND INTERPRETABILITY (09 Periods)

Black-box vs. White-box Models, Techniques: LIME, SHAP, Integrated Gradients, Causal Reasoning and Counterfactual Explanations, Visual Interpretability in CNNs, Trust, Transparency, and Human- in-the-Loop AI, Trade-offs Between Accuracy, Fairness, and Interpretability

UNIT - IV: GOVERNANCE AND ETHICAL AI (09 Periods)

Principles of Ethical AI: Beneficence, Non-Maleficence, Justice, Autonomy, AI Risk Management and Impact Assessment, Accountability, Auditability, and Traceability, Ethical Decision-Making in Autonomous Systems, AI Code of Conducts and Charters, Policy Compliance: GDPR, ISO/IEC 42001, IEEE ECPAIS

UNIT - V: GLOBAL FRAMEWORKS, REGULATIONS, AND CASE STUDIES (09 Periods)

OECD AI Principles, UNESCO Ethics of AI, NIST AI Risk Management Framework, AI Act (EU), India‘s Digital Personal Data Protection Act, Responsible AI from Industry: Google, Microsoft, IBM, Designing Governance Frameworks in Organizations, Capstone Case Study: Auditing and Governing a Real-World ML System.

Total Periods: 45

TEXTBOOKS:

T1. Securing AI and ML Systems: A Practitioner's Guide, Jason Reed, Fatema Ahmed
T2. Fairness and Machine Learning: Limitations and Opportunities, Solon Barocas, Moritz Hardt, Arvind Narayanan
T3. Understanding Artificial Intelligence Ethics and Safety, David Leslie, The Alan Turing Institute

REFERENCE BOOKS:

R1. Algorithmic Bias Detection and Mitigation, Christian Sandvig, Nicholas Diakopoulos
R2. A Survey on Bias and Fairness in Machine Learning, Mehrabi et al., ACM Computing Surveys
R3. Ethically Aligned Design, IEEE Global Initiative

ONLINE RESOURCES & COURSES:

1. Fast.ai - Practical Deep Learning for Coders (Explainability + Bias)
2. Google's Responsible AI Toolkit
3. MIT – Ethics of AI and Big Data (OpenCourseWare)
4. Harvard – Fairness, Accountability, and Transparency in Machine Learning
5. IBM – AI Fairness 360 Toolkit
6. NIST AI RMF (AI Risk Management Framework)

		L	T	P	C
2339671H	**HONORS IN ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING REINFORCEMENT LEARNING AND AUTONOMOUS SYSTEMS (AIML)**	**3**	**0**	**0**	**3**

Pre-Requisites: Machine Learning, Deep Learning.

Course Outcomes:

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

- **CO1.** Explain the basic concepts of reinforcement learning, including rewards, value functions, and policies.
- **CO2.** Apply dynamic programming, Monte Carlo, and temporal difference methods for policy evaluation and control.
- **CO3.** Design and implement model-free learning algorithms such as Q-learning and SARSA.
- **CO4.** Utilize deep reinforcement learning frameworks (e.g., DQN, A3C, PPO) to solve complex tasks.
- **CO5.** Integrate reinforcement learning into autonomous systems like robots and self-driving cars.

SYLLABUS:

UNIT - I: INTRODUCTION TO REINFORCEMENT LEARNING (08 Periods)

What is Reinforcement Learning (RL), Agent-Environment Interface, Markov Decision Processes (MDPs), Rewards, States, Actions, Policies, Value Functions: State and Action Values, Exploration vs. Exploitation, Bellman Equations

UNIT - II: DYNAMIC PROGRAMMING AND MODEL-FREE METHODS (10 Periods)

Dynamic Programming for Policy Evaluation and Improvement, Policy Iteration and Value Iteration, Monte Carlo Methods: Prediction and Control, Temporal Difference Learning: TD(0), TD(λ), SARSA and Q-Learning Algorithms, Eligibility Traces

UNIT - III: DEEP REINFORCEMENT LEARNING (09 Periods)

Function Approximation and Neural Networks, Deep Q-Networks (DQN), Experience Replay and Target Networks, Policy Gradient Methods, Actor-Critic Architecture, Advanced Algorithms: A2C, A3C, DDPG, PPO

UNIT - IV: APPLICATIONS IN AUTONOMOUS SYSTEMS (09 Periods)

Autonomous Decision-Making Frameworks, RL in Robotics: Path Planning and Motion Control, RL in Autonomous Vehicles, Multi-Agent Reinforcement Learning, Safety and Ethical Issues in Autonomous RL, Transfer and Meta-Reinforcement Learning

UNIT - V: SIMULATION, TOOLS, AND REAL-WORLD DEPLOYMENT
(09 Periods)

Simulation Environments: OpenAI Gym, PyBullet, CARLA, Implementing RL with TensorFlow and PyTorch, Case Studies: Robotic Manipulation, Game Playing (Atari, Go), Performance Metrics and Benchmarking, Deployment in Edge and Real-Time Systems, Challenges in Scaling RL

Total Periods: 45

TEXT BOOKS:

T1. Reinforcement Learning: An Introduction, Richard S. Sutton, Andrew G. Barto, 2nd Edition, MIT Press
T2. Reinforcement Learning with TensorFlow, Prashant Reddy, Balaraman Ravindran, Pack
T3. Foundations of Deep Reinforcement Learning, Laura Graesser, Wah Loon Keng

REFERENCE BOOKS:

R1. Deep Learning, Ian Goodfellow, Yoshua Bengio, Aaron Courville, MIT Press
R2. Deep Reinforcement Learning in Action, Alexander Zai, Brandon Brown
R3. Reinforcement Learning and Dynamic Programming Using Function Approximators, Lucian Busoniu, et al

ONLINE COURSES & RESOURCES:

1. CS50‘s Introduction to AI with Python (Harvard)
2. Deep Reinforcement Learning Specialization – Coursera (by University of Alberta)
3. Udacity – Deep Reinforcement Learning Nanodegree
4. Spinning Up in Deep RL – OpenAI
5. David Silver's RL Lectures – DeepMind/YouTube

		L	T	P	C
2339672H	**HONORS IN ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING DEEP LEARNING AND NEURAL NETWORK ARCHITECTURES (AIML)**	**3**	**0**	**0**	**3**

Pre-Requisites: Machine Learning, Deep Learning, Graph Neural Networks

Course Outcomes:

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

- **CO1.** Analyze the theoretical foundations of neural networks and deep learning.
- **CO2.** Implement and train multilayer perceptron's, CNNs, RNNs, and other architectures.
- **CO3.** Analyze and optimize deep learning models using advanced regularization and tuning techniques.
- **CO4.** Evaluate the applicability of different neural network architectures for various AI problems.
- **CO5.** Apply state-of-the-art models such as Transformers and GANs in real-world domains.

Syllabus:

UNIT - I: FOUNDATIONS OF NEURAL NETWORKS (09 Periods)

Introduction to Artificial Neural Networks, Biological Neuron vs. Artificial Neuron, Perceptron, Multilayer Perceptron (MLP), Activation Functions: ReLU, Sigmoid, Tanh, Softmax, Backpropagation and Gradient Descent, Loss Functions: MSE, Cross Entropy, Overfitting, Regularization (L1/L2), Dropout.

UNIT - II: CONVOLUTIONAL NEURAL NETWORKS (CNNS) (10 Periods)

Convolution Operation and Feature Maps, Pooling Layers: Max and Average Pooling, CNN Architectures: LeNet, AlexNet, VGG, ResNet, Transfer Learning and Fine-tuning, Image Classification, Object Detection Basics, Implementation with TensorFlow/PyTorch

UNIT - III: RECURRENT NEURAL NETWORKS (RNNS) AND VARIANTS (09 Periods)

Sequential Data and Time Series, RNN Basics and Backpropagation Through Time (BPTT), Vanishing and Exploding Gradients, LSTM and GRU Architectures, Applications in Text, Speech, and Music, Sequence-to-Sequence Models

UNIT - IV: ADVANCED ARCHITECTURES & OPTIMIZATION (08 Periods)

Autoencoders and Variational Autoencoders (VAEs), Generative Adversarial Networks (GANs), Deep Reinforcement Learning Overview, Batch Normalization,

Early Stopping, Hyperparameter Tuning and Optimization, Performance Metrics and Evaluation

UNIT - V: TRANSFORMER MODELS & APPLICATIONS (09 Periods)

Attention Mechanism and Self-Attention, Transformers and BERT Architecture, Positional Encoding, Multi-head Attention, Pre-trained Language Models and Fine-Tuning, Applications in NLP: Text Classification, Translation, Large Language Models and Transfer Learning

Total Periods: 45

TEXT BOOKS:

T1. Deep Learning, Ian Goodfellow, Yoshua Bengio, and Aaron Courville (MIT Press)
T2. Neural Networks and Deep Learning, Michael Nielsen (Online Book)
T3. Hands-On Machine Learning with Scikit-Learn, Kera's & TensorFlow, Aurelien Geron (O 'Reilly)

REFERENCE BOOKS:

R1. Pattern Recognition and Machine Learning, Christopher M. Bishop
R2. Deep Learning for Computer Vision, Rajalingappaa Shanmugamani
R3. Natural Language Processing with Transformers, Lewis Tunstall, Leandro von Werra, Thomas Wolf
R4. Reinforcement Learning: An Introduction, Richard S. Sutton and Andrew G. Barto

ONLINE COURSES:

1. Deep Learning Specialization – Andrew Ng (Coursera)
2. CS231n: Convolutional Neural Networks for Visual Recognition (Stanford)
3. Fast.ai – Practical Deep Learning for Coders
4. Deep Learning with PyTorch (Udacity)
5. Transformers by Hugging Face (free course)

		L	T	P	C
2339771H	**HONORS IN ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING AI-DRIVEN SOFTWARE ENGINEERING AND DevOps (AIML)**	**3**	**0**	**0**	**3**

Pre-Requisites: Python Programming, Artificial Intelligence, Machine Learning, Natural Language Processing

Course Outcomes:

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

- **CO1.** Describe the role of AI in modern software engineering processes and lifecycle stages.
- **CO2.** Apply AI/ML models for requirements gathering, code generation, defect prediction, and testing.
- **CO3.** Implement intelligent DevOps practices including CI/CD, release automation, and anomaly detection.
- **CO4.** Analyze data from software pipelines to drive informed decisions and improve quality.
- **CO5.** Develop an end-to-end AI-enabled software delivery pipeline with automated learning- based optimizations.

SYLLABUS:

UNIT - I: FOUNDATIONS OF AI-DRIVEN SOFTWARE ENGINEERING (10 Periods)

Introduction to Software Engineering Lifecycle, Traditional vs. AI-Driven Software Development, AI/ML in Software Engineering: Overview and Scope, Natural Language Processing (NLP) for Requirements Engineering, AI for Software Design Recommendation, Intelligent Code Completion (e.g., GitHub Copilot)

UNIT - II: AI IN TESTING AND DEFECT PREDICTION (09 Periods)

Static and Dynamic Testing with AI, Automated Test Case Generation, Defect Detection and Prediction using ML Models, Sentiment and Bug Report Analysis, AI in Refactoring and Code Review, Tools: SonarQube, DeepCode

UNIT - III: DEVOPS PRINCIPLES AND PRACTICES (09 Periods)

DevOps Overview: CI/CD Pipelines, Infrastructure as Code (IaC), Configuration Management Tools: Ansible, Puppet, Monitoring and Logging Tools: Prometheus, Grafana, Containerization and Orchestration: Docker, Kubernetes, Agile and Lean Practices in DevOps

UNIT - IV: AI FOR DEVOPS AUTOMATION AND INTELLIGENCE (09 Periods)

Predictive Analytics for Deployment Success, AI for Log Analytics and Root Cause Analysis, Self- Healing Systems and Auto-Scaling, Feedback Loops in DevOps using Reinforcement Learning, Data- Driven Decision Making in Release Management, ChatOps and AIOps Platforms

UNIT - V: CASE STUDIES AND EMERGING TRENDS (08 Periods)

Case Study: AI-Augmented DevOps in Enterprises, ML-Ops vs. DevOps vs. DataOps, Security in DevOps (DevSecOps), Explainability and Ethics in AI-Driven Software Engineering, Generative AI in Software Development, Future Trends and Industry Standards.

Total Periods: 45

TEXTBOOKS:

T1. Artificial Intelligence and Software Engineering: Status and Future Directions, Tim Menzies, Diomidis Spinelli's.
T2. DevOps: A Software Architect's Perspective, Len Bass, Ingo Weber, Liming Zhu, Addison-Wesley.
T3. AI & Analytics for DevOps, Thomas Erl, Ricardo Puttini, Zaigham Mahmood, Pearson.

REFERENCE BOOKS:

R1. AI in Software Engineering, Carlos Nunes Silva.
R2. The DevOps Handbook, Gene Kim, Jez Humble, Patrick Debois, John Willis.
R3. Machine Learning: B.Techning (AI Systems Engineering Perspective), Andrew Ng.

ONLINE RESOURCES:

1. Coursera – AI for Software Engineering (IBM)
2. DevOps with Microsoft Azure – edX
3. Udacity – AI for DevOps Engineers Nanodegree

		L	T	P	C
2339772H	**HONORS IN ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING APPLIED PROJECT WORK (AIML)**	**0**	**0**	**6**	**3**

Pre-Requisites: Artificial Intelligence, Machine Learning, Deep Learning, Domain-specific knowledge depending on project topic.

Course Outcomes:

On successful completion of the course, student will be able to

CO1. Identify and define real-world problems suitable for AI/ML-based solutions.
CO2. Apply AI/ML algorithms, tools, and frameworks to develop project prototypes.
CO3. Evaluate system performance using standard metrics and testing methodologies.
CO4. Demonstrate awareness of ethical, social, and environmental considerations in project work.
CO5. Work as an effective team member by managing tasks, documentation, and presentations.
CO6. Engage in lifelong learning by applying research skills, innovation, and adaptability to emerging challenges