

# Post Graduate Program in AI and Machine Learning

*With dedicated live sessions on the latest AI topics like generative AI,  
prompt engineering, ChatGPT and more.*



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# About the Program



Artificial Intelligence (AI) and Machine Learning (ML) are among the most sought after and highly compensated digital economy skills. In the past decade, AI has given us self-driving cars, practical speech recognition, effective web search, and a vastly improved understanding of the human genome. AI is so pervasive that we use it dozens of times a day without even realizing it. Many researchers also think it is the best way to make progress towards human-level AI.

Ride this wave and accelerate your career with this acclaimed AI and Machine Learning program. This program features a thorough mix of theory, projects, and extensive hands-on practice, while leveraging Caltech's academic excellence. More importantly, you'll learn about not only the theoretical underpinnings of AI and ML, but also gain the practical know-how to quickly and successfully apply these tools and techniques to new problems.

This program is a blend of self-paced online videos, live virtual classes, hands-on projects, labs and masterclasses. Mentorship sessions will provide you with a high-engagement learning experience and real-world applications, helping you master essential AI and ML skills. This program covers essential mathematical and statistical concepts, as well as Python programming, machine learning, deep learning, generative AI, prompt engineering, explainable AI, ChatGPT, computer vision, natural language processing, and more.

# Key Features of the Program



Caltech CTME program completion certificate



Earn up to 22 CEUs from Caltech CTME



Live interactive sessions by industry experts on latest AI trends, such as generative AI, prompt engineering, and more



Live online masterclasses delivered by Caltech instructors



Caltech CTME Circle Membership



Seamless access to integrated labs



IBM certificates for IBM courses



Access to hackathons and Ask Me Anything sessions from IBM



3 capstones and 25+ hands-on projects from various industry domains



Simplilearn's Career Assistance helps you get noticed by top hiring companies



Gain exposure to ChatGPT, OpenAI, Dall-E, Midjourney & other prominent tools



8X higher interaction in live online classes by industry experts

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# About Caltech CTME

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Founded in 1891, Caltech is a world-renowned science and engineering institute that marshals some of the world's brightest minds and most innovative tools to address fundamental scientific questions and pressing societal challenges. Caltech prizes excellence and ambition. The contributions of Caltech's faculty and alumni have earned national and international recognition, including 38 Nobel Prizes and nearly 60 National Medals of Science. The Institute manages the Jet Propulsion Laboratory (JPL) for NASA.

CTME is embedded in Caltech's Division of Engineering and Applied Science. Caltech CTME has a unique role to play in applying the capabilities of scientists and engineers to the challenges of today's technology-driven businesses. Caltech CTME applies executive education and professional development directly to real-world problems. Caltech CTME experts teach the tools and perspectives that elevate careers and help companies achieve their goals.





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# Eligibility Criteria

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For admission in this program, candidates should have:

- ✓ A bachelor's degree with an average of 50% or higher marks
- ✓ Prior knowledge or experience in programming and mathematics
- ✓ Preferably 2+ years of formal work experience



# Application Process

Candidates can apply to this program in 3 simple steps:



## Submit an Application

Complete the application and include a brief statement of purpose. The latter informs our admissions counselors why you're interested and qualified for the program.



## Application Review

A panel of admissions counselors will review your application and statement of purpose to determine whether you qualify for acceptance.



## Admission

An offer of admission will be made to qualified candidates. You can accept this offer by paying the program fee.

## Talk to an Admissions Counselor

We have a team of dedicated admissions counselors here to help guide you in the application process and related matters. They are available to

- ✓ Address questions related to the application
- ✓ Assist with financial aid (if required)
- ✓ Help you better understand the program and answer your questions

## Who is this Program Ideal for?



This program caters to professionals from a variety of industries and backgrounds. The diversity of our students adds richness to class discussions and interactions. Roles in this space require a combination of experience and an understanding of tools and technologies. This program is ideal for professionals looking for a career transition into the field of AI and ML, who have knowledge or prior experience in programming and mathematics, and an analytical frame of mind.

Professionals eager to develop AI and ML expertise with the objective of:

- ✓ Enhancing effectiveness in their current role
- ✓ Transitioning to AI and ML roles in their organization
- ✓ Seeking to advance their career in the industry
- ✓ Giving shape to entrepreneurial aspirations



# Program Outcomes



Learn about some of the latest AI trends like generative AI, prompt engineering, ChatGPT, and much more



Apply effective prompt engineering techniques to improve the performance and control the behavior of generative AI models



Understand the meaning, purpose, scope, stages, applications, and effects of AI and ML



Gain an in-depth understanding of data science processes, data wrangling, data exploration, data visualization, hypothesis building, and testing



Perform scientific and technical computing using the SciPy package and its sub-packages, such as Integrate, Optimize, Statistics, IO, and Weave



Gain expertise in mathematical computing using the NumPy and scikit-learn package



Master the concepts of supervised and unsupervised learning, recommendation engines, and time series modeling



Validate machine learning models and decode various accuracy metrics



Understand and appreciate Deep Learning and its applications



Gain knowhow of Neural Networks, and traverse the layers of data abstraction which will help you understand data like never before



Explore tools, such as Keras, to build computer vision applications



Become familiar with generative adversarial networks (GANs)



Perform distributed and parallel computing using high-performance GPUs



Learn about natural language understanding and natural language generation



Understand the fundamentals of natural language processing (NLP) using the most popular library, Python's Natural Language Toolkit (NLTK)



Understand how to apply Machine Learning and Deep Learning with NLP



Perform text-to-speech conversion with automated speech recognition



Use Python and TensorFlow to understand reinforcement learning theory



Learn how to solve reinforcement learning problems through a variety of strategies

# Learning Path

## Core Courses



## Electives

- ✓ Advanced: ADL & Computer Vision
- ✓ Advanced: NLP & Speech Recognition
- ✓ Advanced: Reinforcement Learning
- ✓ Academic Masterclass
- ✓ Industry Masterclass

# Foundations: Mathematics & Statistics Essentials

## STEP

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The Mathematics and Statistics Foundations course establishes a strong mathematical and statistical principles base, fostering critical thinking and problem-solving skills. This course equips students with the ability to analyze data, make informed decisions, and apply these techniques to relevant industry scenarios. It serves as an essential starting point for further learning in the program.

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## Learning Outcomes:

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

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- ✓ Understand the key concepts in coordinate geometry and linear algebra

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- ✓ Grasp the principles of eigenvalues, eigenvectors, and eigendecomposition

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- ✓ Develop a solid foundation in calculus, including understanding limits, derivatives, and integrals

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- ✓ Differentiate between various types of statistics

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- ✓ Identify the practical applications of statistics across different business domains

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- ✓ Differentiate between structured and unstructured data
- ✓ Calculate mathematical and positional averages
- ✓ Explore measures of central tendency such as means, medians, deciles, percentiles, modes, and quartiles
- ✓ Define measures of dispersion, including range, quartile deviation, and identification of outliers
- ✓ Describe mean absolute deviation (MAD), standard deviation, and variance



- ✓ Master the concepts of probability
- ✓ Identify independent and dependent events
- ✓ Understand the principles of Bayes' theorem
- ✓ Master techniques used for sampling methods
- ✓ Examine different outcomes of hypothesis testing
- ✓ Perform one-tail and two-tail tests

## Topics Covered

The course covers the following topics:

- ✓ Introduction to Mathematics
- ✓ Coordinate Geometry
- ✓ Linear Algebra
- ✓ Eigenvalues, Eigenvectors, and Eigendecomposition
- ✓ Introduction to Calculus
- ✓ Understanding Data
- ✓ Descriptive Statistics
- ✓ Data Visualization
- ✓ Probability
- ✓ Probability Distributions
- ✓ Sampling and Sampling Techniques
- ✓ Inferential Statistics
- ✓ Application of Inferential Statistics
- ✓ Relationship Between Variables
- ✓ Application of Statistics in Business

# Foundations: Programming Refresher

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This course provides you with essential Python programming skills that will serve as the building blocks for your entire program journey. You will learn how to implement artificial intelligence (AI) and machine learning (ML) algorithms, conduct data analysis, and construct intelligent systems effectively using Python.

## Learning Outcomes:

- ✓ Learn about procedural and object-oriented programming
- ✓ Understand the benefits and advantages of utilizing Python
- ✓ Install Python and its integrated development environment (IDE)
- ✓ Familiarize yourself with Jupyter Notebook and its usage
- ✓ Implement Python identifiers, indentation, and comments effectively
- ✓ Identify Python's data types, operators, and string functions
- ✓ Learn about different types of loops in Python
- ✓ Explore the scope of variables within functions
- ✓ Explain the concepts of object-oriented programming (OOP) and its characteristics
- ✓ Describe methods, attributes, and access modifiers in Python
- ✓ Gain an understanding of multi-threading

## Topics Covered

- ✓ Fundamentals of Programming
- ✓ Introduction to Python Programming
- ✓ Python Data Types and Operators
- ✓ Conditional Statements and Loops in Python
- ✓ Python Functions
- ✓ Object-Oriented Programming Concepts with Python
- ✓ Threading

# Foundations: Python for Data Science (IBM)

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Developed by IBM, this course equips students with the skills to leverage Python for data science. By the end of the course, participants will be proficient in writing Python scripts and performing hands-on data analysis using a Jupyter-based lab environment.

## Learning Outcomes:

Upon completion of the course, participants will be able to:

- ✓ Create their first Python program using variables, strings, functions, loops, and conditions
- ✓ Understand and apply concepts related to lists, sets, dictionaries, conditions, branching, objects, and classes in Python
- ✓ Utilize the pandas library to load, manipulate, and save data, as well as read and write files in Python

## Topics Covered

The course covers the following topics:

- ✓ Python Basics
- ✓ Python Data Structures
- ✓ Python Programming Fundamentals
- ✓ Working with Data in Python
- ✓ Working with NumPy Arrays



# Core: Applied Data Science with Python

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This course provides comprehensive coverage of key concepts in data science, encompassing essential topics such as data preparation, model development, and evaluation. Throughout the course, you will develop a strong understanding of fundamental Python concepts such as strings, Lambda functions, and lists. Additionally, you will explore various important tools and libraries, including NumPy for efficient array manipulation, linear algebra for mathematical foundations, and statistical concepts such as measures of central tendency and dispersion, skewness, covariance, and correlation. The course also delves into hypothesis testing methods such as the Z-test, T-test, and ANOVA while emphasizing data manipulation techniques using Pandas. Furthermore, you will acquire data visualization skills using popular libraries like Matplotlib, Seaborn, Plotly, and Bokeh.

## Learning Outcomes:

- ✓ Explain the fundamental principles and applications of data science
- ✓ Explore the processes involved in data preparation, model building, and evaluation
- ✓ Apply Python concepts, including strings, Lambda functions, and lists
- ✓ Develop a strong understanding of NumPy and its application in array indexing and slicing
- ✓ Gain familiarity with linear algebra principles and their relevance in data science
- ✓ Understand the role of calculus in linear algebra applications
- ✓ Calculate and interpret measures of central tendency and dispersion

- ✓ Grasp statistical concepts such as skewness, covariance, and correlation
- ✓ Describe the concepts of the null hypothesis and alternate hypothesis
- ✓ Examine different hypothesis tests, including the Z-test and T-test
- ✓ Understand the concept of ANOVA (Analysis of Variance)
- ✓ Work effectively with pandas' primary data structures: Series and DataFrame
- ✓ Utilize pandas to load, index, reindex, and merge data
- ✓ Prepare, format, normalize, and standardize data using techniques like data binning
- ✓ Construct visually appealing and informative graphs using Matplotlib, Seaborn, Plotly, and Bokeh

## Topics Covered

- ✓ Introduction to Data Science
- ✓ Essentials of Python Programming
- ✓ NumPy
- ✓ Linear Algebra
- ✓ Statistics Fundamentals
- ✓ Probability Distributions
- ✓ Advanced Statistics
- ✓ Working with Pandas
- ✓ Data Analysis
- ✓ Data Wrangling
- ✓ Data Visualization
- ✓ End-to-End Statistics Application in Python

# Core: Machine Learning

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This course provides comprehensive coverage of various types of machine learning and their practical applications. You will explore the machine learning pipeline and delve into topics such as supervised learning, regression models, and classification algorithms. You will also study unsupervised learning, including clustering techniques and ensemble modeling. Evaluate machine learning frameworks like TensorFlow and Keras, and build a recommendation engine with PyTorch.

## Learning Outcomes:

- ✓ Examine the different types of machine learning and their characteristics
- ✓ Analyze the machine learning pipeline and understand the operations involved in MLOps (Machine Learning Operations)
- ✓ Learn about supervised learning and its real-world applications
- ✓ Understand the concepts of overfitting and underfitting, and learn how to detect and prevent both
- ✓ Analyze different types of regression models and their applications
- ✓ Identify linearity between variables and create correlation maps
- ✓ List various types of classification algorithms and understand their applications
- ✓ Master different types of unsupervised learning techniques
- ✓ Determine when to use unsupervised algorithms and explore different clustering methods
- ✓ Examine various ensemble modeling techniques such as bagging, boosting, and stacking

- ✓ Evaluate different machine learning frameworks, including TensorFlow and Keras
- ✓ Build a recommendation engine using the PyTorch library

## Topics Covered

- ✓ Machine Learning Fundamentals
- ✓ Supervised Learning
- ✓ Regression Models and Applications
- ✓ Classification Models and Applications
- ✓ Unsupervised Learning
- ✓ Ensemble Learning
- ✓ Recommendation Systems



# Core: Deep Learning with TensorFlow (IBM)

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Elevate your machine learning skills to the next level with this comprehensive course on deep learning using TensorFlow and Keras. Gain a thorough understanding of deep learning concepts, empowering you to construct artificial neural networks and navigate through complex data abstraction layers. By harnessing the potential of data, this course prepares you to venture into new frontiers of Artificial Intelligence.

## Learning Outcomes:

Upon completion of the course, participants will be able to:

- ✓ Develop a deep understanding of neural networks and effectively apply them in deep learning scenarios
- ✓ Acquire proficiency in TensorFlow and Keras, which are indispensable tools for deep learning
- ✓ Explore the practical applications of convolutional neural networks (CNNs)
- ✓ Familiarize yourself with recurrent neural networks (RNNs) and autoencoders
- ✓ Optimize the performance of neural networks using techniques such as L2 regularization and dropout layers
- ✓ Create autoencoder models to detect anomalies in data

## Topics Covered:

- ✓ Introduction to Artificial Intelligence and Deep Learning
- ✓ Artificial Neural Network
- ✓ Deep Neural Network and Tools
- ✓ Optimization, Tuning, and Interpretability of Deep Neural Networks
- ✓ Convolutional Neural Networks (CNN)
- ✓ Recurrent Neural Networks
- ✓ Autoencoders

# Core: Deep Learning Specialization

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This comprehensive course provides you with the necessary skills to deploy deep learning tools using AI/ML frameworks. You will explore the fundamental concepts and applications of deep learning and understand the distinctions between deep learning and machine learning. The course covers a range of topics, including neural networks, forward and backward propagation, TensorFlow 2, Keras, performance improvement techniques, model interpretability, convolutional neural networks (CNNs), transfer learning, object detection, recurrent neural networks (RNNs), autoencoders, and creating neural networks in PyTorch. By the end of the course, you will have a solid foundation in deep learning principles and the ability to effectively build and optimize deep learning models using Keras and TensorFlow.

## Learning Outcomes:

- ✓ Gain an understanding of the differences between deep learning and machine learning.
- ✓ Learn about the practical applications of deep learning.
- ✓ Understand different types of neural networks
- ✓ Master the concepts of forward propagation and backward propagation in deep neural networks (DNN)
- ✓ Get introduced to modeling and performance improvement techniques in deep learning
- ✓ Comprehend hyperparameter tuning and model interpretability
- ✓ Learn about dropout and early stopping techniques and their implementation
- ✓ Master convolutional neural networks (CNNs) and object detection

- ✓ Grasp the fundamentals of recurrent neural networks (RNNs)
- ✓ Understand the basics of PyTorch and learn how to create a neural network using PyTorch

## Topics Covered:

- ✓ Introduction to Deep Learning
- ✓ Artificial Neural Networks
- ✓ Deep Neural Networks
- ✓ TensorFlow
- ✓ Model Optimization and Performance Improvement
- ✓ Convolutional Neural Networks (CNNs)
- ✓ Transfer Learning
- ✓ Object Detection
- ✓ Recurrent Neural Networks (RNNs)
- ✓ Transformer Models for Natural Language Processing (NLP)
- ✓ Getting Started with Autoencoders
- ✓ PyTorch

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# Core: Essentials of Generative AI, Prompt Engineering & ChatGPT

This course offers a thorough exploration of generative AI models, specifically emphasizing ChatGPT. Participants will acquire a comprehensive grasp of the fundamentals of generative AI and its scope, prompt engineering, explainable AI, conversational AI, ChatGPT, other large language models and much more.

## Learning Outcomes:

- ✓ Acquire a solid foundation in generative AI models, encompassing their core principles and various types of generative AI models.
- ✓ Grasp the concept of explainable AI, understand its importance, and distinguish between different approaches for achieving explainability in AI systems.
- ✓ Utilize effective prompt engineering techniques to enhance performance and regulate the behavior of generative AI models.
- ✓ Develop a comprehensive understanding of ChatGPT, including its operational mechanisms, notable features, and limitations.
- ✓ Explore a range of applications and scenarios where ChatGPT can be effectively utilized.
- ✓ Familiarize yourself with fine-tuning techniques to personalize and optimize ChatGPT models.
- ✓ Recognize the ethical challenges of generative AI models to ensure responsible data usage, mitigate bias and prevent misuse.
- ✓ Comprehend the transformative potential of generative AI across industries and explore prominent generative AI tools.
- ✓ Gain insights into the future of generative AI, its challenges, and the necessary steps to unlock its full potential.

## Topics Covered:

- ✓ Generative AI and its Landscape
- ✓ Explainable AI
- ✓ Conversational AI
- ✓ Prompt Engineering
- ✓ Designing and Generating Effective Prompts
- ✓ Large Language Models
- ✓ ChatGPT and its Applications
- ✓ Fine-tuning ChatGPT
- ✓ Ethical Considerations in Generative AI Models
- ✓ Responsible Data Usage and Privacy
- ✓ The Future of Generative AI
- ✓ AI Technologies for Innovation



# Capstone Project

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The capstone project allows you to implement the skills you will learn throughout this program. You will solve industry-specific challenges by leveraging various AI and ML techniques. The capstone project is the final step in the core learning path and will help you showcase your expertise to employers.

## Learning Outcomes:

- ✓ The capstone project will enhance your understanding of the Artificial Intelligence decision cycle, including performing exploratory data analysis, building and fine-tuning a model with cutting-edge AI-based algorithms, and representing results.

## Electives

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## Advanced: Advanced Deep Learning and Computer Vision

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In this advanced course, you will gain in-depth knowledge and practical skills in computer vision and deep learning techniques. The course covers various topics, including image formation and processing, convolutional neural networks (CNNs), object detection, image segmentation, generative models, optical character recognition, distributed and parallel computing, explainable AI (XAI), and deploying deep learning models. By the end of the course, you will have the expertise to tackle complex computer vision challenges and successfully deploy deep learning models.

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## Advanced: Natural Language Processing and Speech Recognition

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This advanced course comprehensively explores applying machine learning algorithms to process vast amounts of natural language data. It focuses primarily on natural language understanding, feature engineering, natural language generation, automated speech recognition, speech-to-text conversion, text-to-speech conversion, voice assistance devices, and building Alexa skills. By the end of the course, you will have a deep understanding of the science behind natural language processing and speech recognition, enabling you to develop advanced applications in these areas.

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# Advanced: Reinforcement Learning

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This course delves into the core concepts of reinforcement learning (RL), providing you with the knowledge and skills to solve RL problems using various strategies in Python and TensorFlow. You will learn the theoretical foundations of RL and gain practical experience in applying RL algorithms as a problem-solving strategy. By the end of the course, you will be equipped with the skills to use reinforcement learning in diverse applications and scenarios effectively.

## Academic Masterclass- Caltech CTME

Attend this live online Masterclass conducted by Caltech CTME instructors and get insights about advancements in the AI and Machine Learning domain.

## Industry Masterclass

Attend this live interactive industry masterclass to gain insights about latest advancements in AI and Machine Learning domain

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# Skills Covered

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- ✓ Generative AI
- ✓ Prompt Engineering
- ✓ ChatGPT
- ✓ Explainable AI
- ✓ Statistics
- ✓ Machine Learning Algorithms
- ✓ Supervised and Unsupervised Learning
- ✓ Model Training and Optimization
- ✓ Model Evaluation and Validation
- ✓ Ensemble Methods
- ✓ Deep Learning
- ✓ Natural Language Processing
- ✓ Computer Vision
- ✓ Reinforcement Learning
- ✓ Speech Recognition

## Tools Covered

matplotlib

TensorFlow

learn

python™

K Keras



DALL-E 2

OpenCV

NLTK

G Bard



OCR

NumPy

PyTorch

# Projects

## Project 1

### Ecommerce

Develop a shopping app for an ecommerce company using Python

## Project 2

### Food Service

Using data science techniques, such as time series forecasting, to help a data analytics company forecast demand for different restaurant items.

## Project 3

### Retail

Use exploratory data analysis and statistical techniques to understand the factors contributing to a retail firm's customer acquisition.

## Project 4

### Production

Perform feature analysis to understand the features of water bottles using EDA and statistical techniques to understand their overall quality and sustainability.

## Project 5

### Real Estate

Use feature engineering to identify the top factors that influence price negotiations in the homebuying process.

## Project 6

### Entertainment

Perform cluster analysis to create a recommended playlist of songs for users based on their user behavior.

## Project 7

### Human Resources

Build a machine learning model that predicts employee attrition rate at a company by identifying patterns in their work habits and desire to stay with the company.

## Project 8

### Shipping

Use deep learning concepts, such as Convolutional Neural Networks (CNN), to automate a system that detects and prevents faulty situations resulting from human error and identifies the type of ship entering the port.

#### Project 9

### BFSI

Use deep learning to construct a model that predicts potential loan defaulters and ensures secure and trustworthy lending opportunities for a financial institution.

#### Project 10

### Healthcare

Use distributed training to construct a CNN model capable of detecting diabetic retinopathy and deploy it using TensorFlow Serving for an accurate diagnosis.

#### Project 11

### Healthcare

Leverage deep learning algorithms to develop a facial recognition feature that helps diagnose patients for genetic disorders and their variations.

#### Project 12

### Automobile

Examine accident data involving Tesla's auto-pilot feature to assess the correlation between road safety and the use of auto-pilot technology.

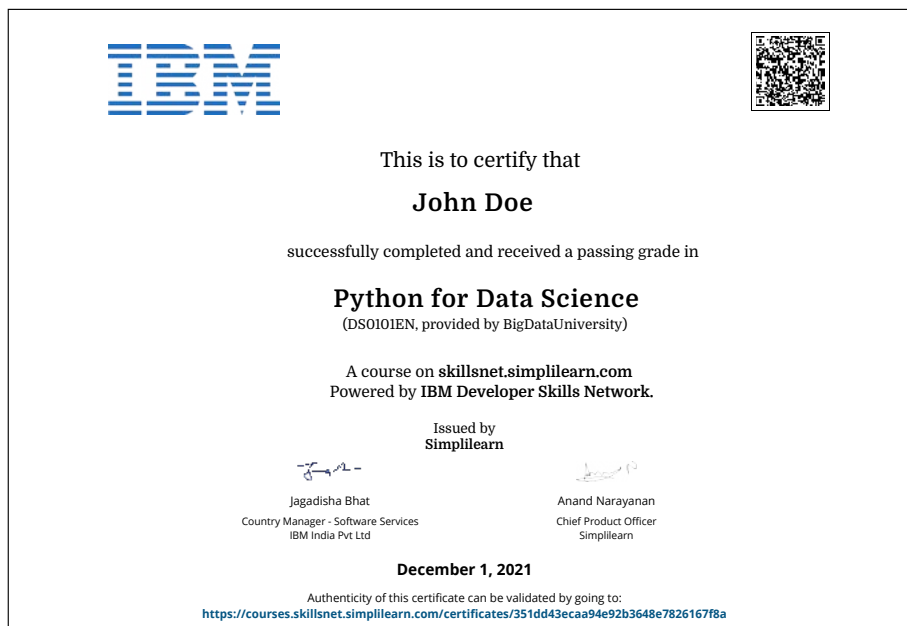
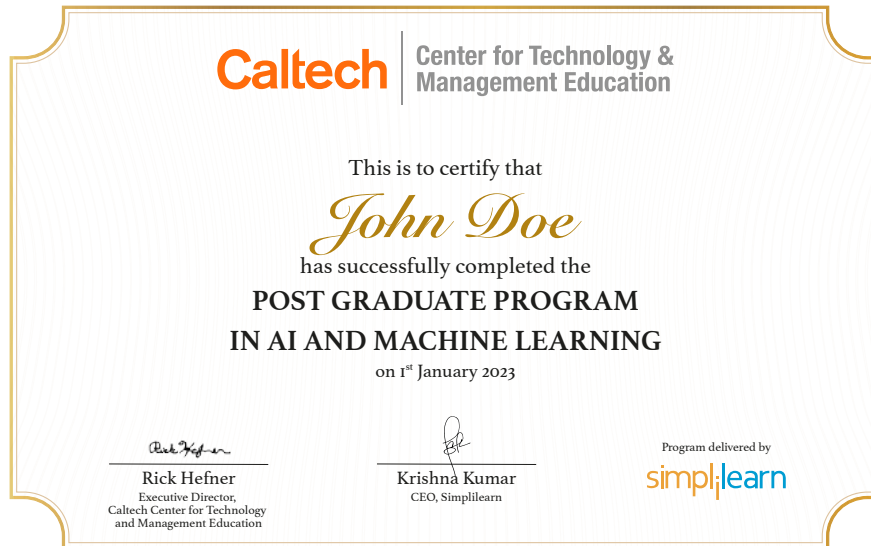
#### Project 13

### Tourism

Use AI to categorize images of historical structures and conduct exploratory data analysis (EDA) to build a recommendation engine that improves marketing initiatives for historic locations.



## Certificates



Upon successful completion of this program, you will receive a certificate of completion from Caltech CTME. You will also receive IBM certificates (sample IBM certificate shown above) for all IBM courses, along with certificates from Simplilearn for the courses completed in the learning path. These certificates will testify to your skills as an AI and ML expert.

# Advisory Board Member



## Rick Hefner

Program Director, Caltech Center for Technology & Management Education

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Rick Hefner, PhD, specializes in systems development and maintenance; project management; Lean Six Sigma; process improvement, technology transfer; and risk management. His experience spans over 35 years. Dr. Hefner recently served as Director of Process Management at Northrop Grumman Corporation, where he managed corporate process initiatives related to Lean Six Sigma and program management.

Previous positions at Northrop Grumman (formerly TRW) included managing technology process initiatives and helping to establish the corporate engineering and program management processes. Previously, at Aerospace Corporation, Dr. Hefner was the Director of their Software Development department. He served as an engineer, technical specialist, project manager, and section manager.

Dr. Hefner has also worked with companies in the communications, electronics, and health sciences industries, including Applied Physics Laboratory, Ares Management, Boeing, DRS Technologies, Herbalife, Honeywell, Jet Propulsion Laboratory, John Deere, L-3 WESCAM, Maytag, Motorola, Pacific Bell, Raytheon, Schlumberger, Southern California Edison, St. Jude Medical, Toshiba, U.S. Navy, and Xerox. Dr. Hefner is credited with over 200 publications and presentations. He earned his PhD from the University of California, Los Angeles, in applied dynamic systems control. He received his MS and BS from Purdue University in interdisciplinary engineering.



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Disclaimer: All programs are offered on a non-credit basis and are not transferable to a degree.