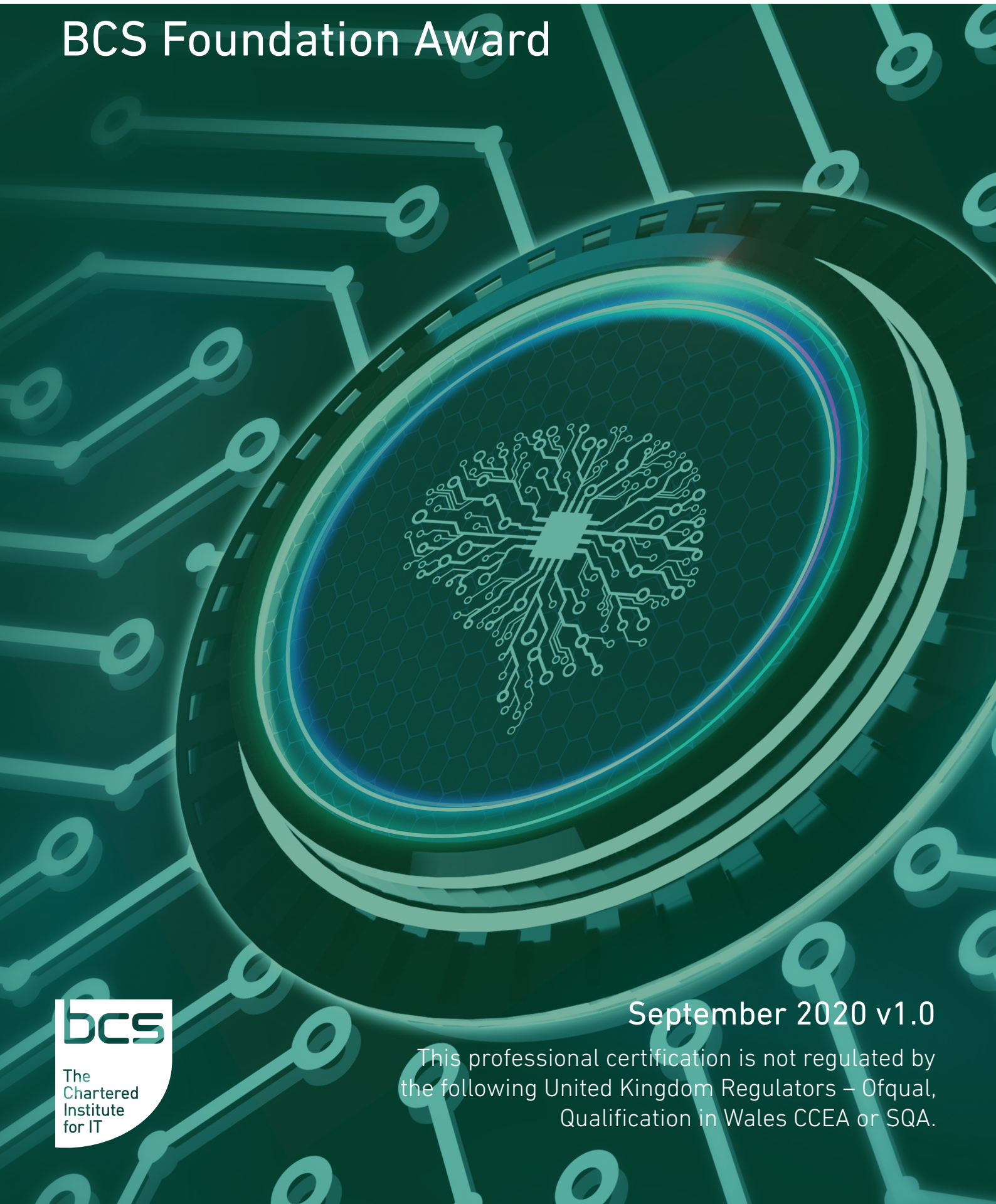
Machine Learning

BCS Foundation Award



The Chartered Institute for IT

September 2020 v1.0

This professional certification is not regulated by the following United Kingdom Regulators – Ofqual, Qualification in Wales CCEA or SQA.

CONTENTS

Document Change History

Any changes made to the syllabus shall be clearly documented with a change history log. This shall include the latest version number, date of the amendment and changes made. The purpose is to identify quickly what changes have been made.

Version Number	Changes Made
V1.0	Document Creation

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Introduction

The BCS Foundation Award in Machine Learning is designed for individuals wishing to gain an understanding of the principles of Machine Learning and the process through which it can be developed.

The term “Machine Learning” has increased in popularity in the last decade and is a technology which is becoming more commonly used within many organisations. With its ability to help solve business problems and develop new customer experiences, there is now a greater demand for individuals with the knowledge and skills to support organisations to successfully implement the technology to deliver improvements.

This award explores what Machine Learning is and how it is used in practice. It provides an introduction into the different types of Machine Leaning and the tools and techniques required to develop it, including a basic introduction to algorithms. This award will enable candidates to understand these concepts at a foundation level, enabling them to be better informed and equipping them with knowledge which they can build upon through further study and application.

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Qualification Suitability and Overview

The BCS Foundation Award in a Machine Learning has been designed for individuals interested in furthering their understanding of the more technical aspects of AI. This Foundation Award is ideal for candidates who wish to gain an insight into this type of AI technology. Machine Learning is becoming much more commonly used, therefore it is useful for anyone, regardless of being in IT or in a technical position, to understand what Machine Learning is, its potential uses and its limitations.

This award has been created alongside a selection of other awards in the AI space which offer candidates a clear pathway of progression into other disciplines of IT along with a broader knowledge of AI in the workplace. This makes it ideally suited for those looking for a change in career, an upskilling workforce, sustainable employers and individuals with a background in: science, engineering, knowledge engineering, finance, education or IT services.

This award represents 5 credits that can count towards the credits required for a BCS Foundation Certificate or Diploma in a relevant discipline.

Candidates can study for this award by attending a training course provided by a BCS accredited Training Provider or through self study.

Total Qualification Time	Guided Learning Hours	Independent Learning	Assessment Qualification Time	Credits
50 hours	16 hours	33.5 hours	0.5 hours	5

*Examples of Independent Learning include reading of articles or books, watching videos, attendance of other types of training or work shadowing.

Trainer Criteria

It is recommended that to effectively deliver this award, trainers should possess:

- BCS Foundation Certificate in Artificial Intelligence or similar qualification.
- A minimum of 2 years’ training experience or a recognised training qualification.

SFIA Levels

This award provides candidates with the level of knowledge highlighted within the table, enabling candidates to develop the skills to operate successfully at the levels of responsibility indicated.

Level	Levels of Knowledge	Levels of Skill and Responsibility (SFIA)
K7		Set strategy, inspire and mobilise
K6	Evaluate	Initiate and influence
K5	Synthesise	Ensure and advise
K4	Analyse	Enable
K3	Apply	**Apply**
K2	**Understand**	**Assist**
K1	**Remember**	**Follow**

SFIA Plus

This syllabus has been linked to the SFIA knowledge skills and behaviours required by an individual at level 3;

KSB01

Acquiring a proper understanding of a problem or situation by breaking it down systematically into its component parts and identifying the relationships between these parts. Selecting the appropriate method/tool to resolve the problem and reflecting critically on the result, so that what is learnt is identified and assimilated.

KSB03

Understanding the metrics associated with a problem or situation, their significance and relationship, and being able to manipulate these as necessary to identify solutions.

KSC16

A set of codes and syntax (supported by software tools) which enable the unambiguous translation of specified functionality into "source code" for the creation of computer programs. Examples, but not limited to: Scripting languages - Perl and other languages - C++.
Methods and techniques for ensuring valid results are obtained by means of sampling.

Further detail around the SFIA Levels can be found at www.bcs.org/levels.

Learning Outcomes

Upon completion of the award, candidates will be able to demonstrate:

1. An understanding of the basic principles of machine learning
2. A basic understanding of the use of coding languages and software used in Machine Learning
3. An understanding of the different types of algorithms used in machine learning
4. An understanding of the key stages within the Machine Learning process

Syllabus

1. What is Machine Learning? (20%) (K1/2)

Candidates will be able to:

1.1 Define Machine Learning.

Indicative content	Guidance
a. Machine Learning a subset of AI b. "Learning from experience" c. Tom Mitchell – definition (Academic) iterative, continuous learning (Machine Learning 1997, first publication, 2013) d. Requirement for talent for learning/mathematics (i.e. Data Scientist) e. Application of algorithms to given data to derive insight	It is important for learners to understand that Machine Learning is a subset of A (Artificial Intelligence). AI itself is not a new concept; Machine Learning is another step in the evolution of AI. Machine Learning is used within Data Science and is the application of algorithms to derive insight from data and Big Data.

Syllabus

1. What is Machine Learning? (20%) (K1/2)

Candidates will be able to:

1.2 Explain different applications of Machine Learning.

Indicative content

a. Prediction
b. Object recognition
c. Classification
d. Clustering
e. Recommendations (e.g. Netflix, Spotify)

Guidance

Machine Learning can be used in a number of contexts to complete different types of tasks. Learners should be encouraged to explore different examples and applications of Machine Learning.

Candidates will be able to:

1.3 Describe the role of a Learning Agent.

Indicative content

a. Data
b. Single task
c. Learning from experience

Guidance

Learning Agents are commonly used in Machine Learning. Each agent is designed to undertake a specific task using a given amount of data, which they undertake autonomously. Through the repetition of undertaking this task they learn to improve each time. Examples include chat bots, driverless cars, facial recognition.

Candidates will be able to:

1.4 Explain the concept of Deep Learning.

Indicative content

a. Universal technique to solve a larger set of problems
b. Neural Networks combined with large data sets

Guidance

The application of Deep Learning (a subset of Machine Learning) involves the training of large Neural Networks to process and analyse vast amounts of data to derive greater insight and to solve more complex problems.

Candidates will be able to:

1.5 Describe the purpose of a Neural Network.

Indicative content

a. Input > Identify patterns in data > Output
b. Decision Making

Guidance

Neural Networks are commonly used in Machine Learning, particularly in the analysis of unstructured or unlabelled data (e.g. images, handwritten documents), whereby the input data is analysed to determine any recognisable or similar patterns against other learned bits of data in order to determine the output.

Learners may wish to explore the concept of a Neural Network by considering technologies that use Machine Learning such as voice recognition software where the input (captured user's voice) is analysed and compared against stored patterns (data) to identify the output (a specific action, acceptance of voice command, text-to-speech).

Syllabus

1. What is Machine Learning? (20%) (K1/2)

Candidates will be able to:

1.6 Illustrate how Machine Learning compliments Knowledge-Based Systems.

Indicative content

a. Knowledge-Based Systems
b. Complimentary AI technologies

Guidance

A Knowledge-Based System is a form of AI designed to capture human expertise/knowledge (within a knowledge base) and apply a set of rules to identify an outcome (through an inference engine). Machine Learning is data-based and can derive outcomes through the use of algorithms e.g. a Neural Network.

Technologies such as Driverless cars may use a combination of different AI applications to perform different tasks. It may include a Knowledge-Based System to make informed decisions or identity the probable cause of a fault, and it may use a Neural Network for image recognition for navigation using the car's camera.

Candidates will be able to:

1.7 Explain the process through which Machine Learning works with Data.

Indicative content

a. The Machine Learning process
b. Analyse the problem
c. Data Selection
d. Data Pre-processing
    - Cleaning
    - Integration
    - Transformation
    - Reduction
    - Wrangling
e. Data Visualisation
f. Select a Machine Learning model (algorithm)
    - Train the model
    - Test the model
    - Repeat (Learning from experience to improve results)
g. Review
    - Peer review
    - Learning from multiple algorithms
    - Identify best Machine Learning model

Guidance

The Machine Learning process allows us to define the solution based on the problem that has been identified through the process of data selection, pre-processing, visualisation and testing of data with specific algorithms. Once we are happy that both the data and the algorithms we have chosen to use are performing well we can deploy our model.

The Machine Learning process is explored in detail in a book from Google director (Machine Learning steps) Aurélien Géron; recognise the problem, define data, check algorithms, improve results, present results. There is no defacto method within Machine Learning, learning through experience is vitally important. Testing involves creating the correct test data, creating bins to learn from and bins for what you wish to test.

Syllabus

2. Coding for Machine Learning (20%) (K1)

Candidates will be able to:

2.1 Explain the use of at least one coding language used in machine learning.

Indicative content

a. Object-oriented programming languages
   - Python
   - R
   - C++
   - Java

b. Libraries/templates

Guidance

Learners should be familiar with common programming languages and their use, although it is not expected that they are fluent in using them. Python is a very popular language used in Machine Learning and Data Science. Libraries are used to bundle functions into templates that include the use of different programming languages e.g. Python.

Candidates will be able to:

2.2 Identify common open source and proprietary software used in coding for Machine Learning.

Indicative content

a. Tensorflow
b. R Studio
c. Cuda
d. Scikit-Learn
e. MATLAB

Guidance

Learners should be encouraged to explore some of the known software and programming environments used in programming Machine Learning. It is not expected that they are proficient in their use however they should be familiar with at least one software.

3. Algorithms Used in Machine Learning (30%) (K1/2)

Candidates will be able to:

3.1 Explain the use of mathematics in enabling a machine to solve numerical problems.

Indicative content

a. Probability (Bayes Theorem)
b. Statistics
   - Descriptive Statistics
   - Inferential Statistics

c. Linear Algebra

Guidance

It is important for learners to have a basic understanding of the mathematics used within Machine Learning, regardless of whether the software they go on to use handles this automatically. Bayes Theorem is a method which can be used to calculate probability where other probabilities are known.

Understanding the basic principles of Linear Algebra will provide them with the foundation on which to better understand Machine Learning and in implementing algorithms.

Syllabus

3. Algorithms Used in Machine Learning (30%) (K1/2)

Candidates will be able to:

3.2 List and describe typical algorithms used in Machine Learning.

Indicative content

a. Regression algorithms (e.g.)
   - Linear regression
   - Polynomial Regression

b. Classification algorithms (e.g.)
   - K-Nearest Neighbours
   - Decision Trees
   - Logistic Regression

c. Clustering algorithms (e.g.)
   - K-means
   - Hierarchical

Guidance

Learners should have a basic understanding of some of the common algorithms used in Machine Learning and where they may be used in Supervised or Unsupervised learning. It is not essential at this level for them to understand the specific formulas used within each algorithm, however it is certainly advantageous to have a basic understanding of the maths involved in order to make it easier to programme Machine Learning.

You may wish to further challenge learners by looking into the use of Boosting, Decision Forests, and Ensembles.

Candidates will be able to:

3.3 Describe Supervised, Unsupervised and Semi-Supervised learning.

Indicative content

a. Supervised learning
b. Unsupervised learning
c. Semi-Supervised learning

Guidance

It is useful for learners to have a basic understanding of the different types of approaches to Machine Learning to understand how it can be used to work with different types of data and where different algorithms are best used.

Supervised learning involves the application of an algorithm to labelled data to solve a problem, for example Classification, where we know what the output will be.

Unsupervised learning involves the application of an algorithm to unlabelled data to solve a problem, for example Clustering (grouping data based on similarities).

Semi-supervised learning involves the application of an algorithm where during the training of the algorithm we begin with a small amount of labelled data and then introduce a larger amount of unlabelled data.

Learners may be encouraged to also consider Reinforcement learning which is commonly used in gaming.

Syllabus

4. Machine Learning in Practice (30%) (K1/2)

Candidates will be able to:

4.1 Describe a particular problem that can be addressed through the use of Machine Learning.

Indicative content

a. Problem identification
b. Requirements for data collection
c. Proposing the Machine Learning solution

Guidance

Learners should be encouraged to identify a specific problem which could be solved through implementing Machine Learning.

Candidates will be able to:

4.2 Outline typical tasks required in the preparation of data for developing a particular application of Machine Learning.

Indicative content

a. Data Pre-processing
b. Data Transformation
c. Importing/loading data

Guidance

Learners should be able to outline the tasks they would need to undertake to prepare the data for use within an application of Machine Learning. This may include steps such as cleaning the data, data validation, and data transformation to ensure it is in a suitable format for using within a chosen software.

Candidates will be able to:

4.3 Explain the process of training a Machine Learning model.

Indicative content

a. Requirements for training
b. Setting up training bins for data
c. Selecting an algorithm Rules
d. Supervised, Unsupervised,
e. Semi-supervised

Guidance

Learners should be able explain the process of training a particular algorithm using their prepared data.

Candidates will be able to:

4.4 Explain the process of testing a Machine Learning model.

Indicative content

a. Testing
b. Tuning
c. Ensembles
d. Statistical testing
e. Review

Guidance

Learners should be able to explain the process through which they tested a particular algorithm using their prepared data and how they identified whether it was performing well. They may use a number of methods to test their algorithm, and they may wish to test and compare multiple algorithms.

Syllabus

4. Machine Learning in Practice (30%) (K1/2)

Candidates will be able to:

4.5 Discuss how to evaluate the results of testing in order to identify the information to be shared

Indicative content

a. Evaluating findings
b. Identifying relevant information for your stakeholders/context
   - What have we learned?
   - Have we been able to address the problem?
   - What next?
   - Learning from experience
c. Drawing conclusions
d. Communication techniques/ methods

Guidance

Learners should be able to explain how they would go about identifying the key pieces of information to share with their stakeholders. They should also explain key considerations for sharing information with stakeholders e.g. type of information, presentation, language and use of technical terms, being prepared to answer questions.

Examination Format

This award is assessed through completion of an invigilated online exam which candidates will only be able to access at the date and time they are registered to attend.

Type	16 Multiple Choice questions, 2 Scenario Based Questions
Duration	30 minutes
Supervised	Yes
Open Book	No (no materials can be taken into the examination room)
Passmark	13/20 (65%)
Delivery	Digital format only.

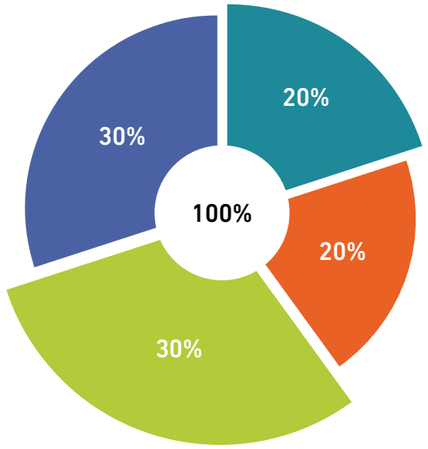
Adjustments and/or additional time can be requested in line with the BCS reasonable adjustments policy for candidates with a disability, or other special considerations including English as a second language.

Question Weighting

Each major subject heading in this syllabus is assigned a percentage weighting. The purpose of this is:

1. Guidance on the proportion of content allocated to each topic area of an accredited course.
2. Guidance on the proportion of questions in the exam.

Syllabus Area	Question type	
1. What is Machine Learning?	Multiple Choice	**20%**
2. Coding for Machine Learning	Multiple Choice	**20%**
3. Algorithms Used in Machine	Scenario Based Multiple Choice	**30%**
4. Machine Learning in Practice	Scenario Based Multiple Choice	**30%**



Syllabus Weighting

20% 20% 30% 30%

Recommended Reading

The following titles are suggested reading for anyone undertaking this award. Candidates should be encouraged to explore other available sources.

Title: Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems
Author: Aurélien Géron
Publisher: O'Reilly
Publication Date: 2017
ISBN: 1491962291

Title: Machine Learning
Author: Tom Mitchell
Publisher: McGraw-Hill
Publication Date: 1997
ISBN: 0071154671

Title: Machine Learning for Absolute Beginners: A Plain English Introduction (2nd edition)
Author: Oliver Theobald
Publisher:
Publication Date: 2017
ISBN: 1549617214

Title: Linear Algebra and Learning from Data (1st edition)
Author: Gilbert Strang
Publisher: Wellesley-Cambridge Press
Publication Date: 2019
ISBN: 13 978-0692196380

Title: Machine Learning
Publisher: The Royal Society
URL: https://royalsociety.org/topics-policy/projects/machine-learning/

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