



# **BCS Essentials Certificate in Artificial Intelligence Syllabus**

**Version V1.3**  
**November 2023**

## Change History

This log provides a single point of reference, where a summary of any changes is recorded, to include the date of the amendment and a summary of the changes made.

| <b>Version Number</b>        | <b>Changes Made</b>                           |
|------------------------------|---|
| Version 1.3<br>November 2023 | Reading list updated                          |
| Version 1.2<br>August 2023   | SPAG changes throughout.                      |
| Version 1.1<br>July 2019     | Correction to Trainer Criteria                |
| Version 1.0<br>February 2019 | Signed off; made live                         |
| Version 0.6<br>January 2019  | Reading list updated                          |
| Version 0.5<br>December 2018 | Added additional LOs: 2.4, 2.5, 3.3, 3.4, 3.5 |
| Version 0.4<br>October 2018  | BCS Formatted syllabus created.               |

## Contents

|  |    |
|--|----|
| Change History .....   | 2  |
| Introduction .....   | 4  |
| Levels of Knowledge / SFIA Levels .....  | 4  |
| Learning Outcomes.....   | 4  |
| Target Audience.....   | 5  |
| Course Format and Duration.....  | 5  |
| Examination Format and Duration.....   | 6  |
| Eligibility for the Examination .....  | 6  |
| Additional Time .....  | 6  |
| Guidelines for Accredited Training Organisations.....                            | 7  |
| Exam Weighting .....   | 7  |
| Syllabus .....   | 8  |
| Learning Objectives .....  | 8  |
| 1 Artificial and Human Intelligence: an Introduction and History (25%).....      | 8  |
| 2 Examples of AI: Benefits, Challenges and Risks (30%) .....                     | 8  |
| 3 An introduction to Machine Learning (35%).....                                 | 8  |
| 4 The Future of Artificial Intelligence – Human and Machine Together (10%) ..... | 9  |
| Recommended Reading List .....   | 10 |
| Abbreviations .....  | 12 |
| Glossary of Terms.....   | 12 |

## Introduction

Artificial Intelligence (AI) is a methodology for using a non-human system to learn from experience and imitate human intelligent behaviour. The BCS Essentials Certificate in Artificial Intelligence tests a candidate's knowledge and understanding of the terminology and the general principles. This syllabus covers the potential benefits; types of Artificial Intelligence; the basic process of Machine Learning (ML); the challenges and risks associated with an AI project, and the future of AI and Humans in work.

## Levels of Knowledge / SFIA Levels

This syllabus will provide candidates with the levels of difficulty highlighted within the following table, also enabling them to develop the skills to operate at the highlighted level of responsibility (as defined within the SFIA framework) within their workplace. The levels of knowledge and SFIA levels are further explained on the [website](#).

| Level | Levels of Knowledge | Levels of Skill and Responsibility (SFIA) |
|-------|---------------------|---|
| 7     |                     | Set strategy, inspire and mobilise        |
| 6     | Evaluate            | Initiate and influence                    |
| 5     | Synthesise          | Ensure and advise                         |
| 4     | Analyse             | Enable                                    |
| 3     | Apply               | Apply                                     |
| 2     | Understand          | Assist                                    |
| 1     | Remember            | Follow                                    |

## Learning Outcomes

Candidates should be able to demonstrate a basic knowledge and understanding of general concepts in the following areas:

1. Human and Artificial Intelligence;
2. The Machine Learning process;
3. The benefits, challenges and risks of a Machine Learning project;
4. The future of humans and machines in Work.

## Target Audience

The Artificial Intelligence Essentials certificate is focussed on individuals with an interest in, (or need to implement) AI in an organisation, especially those working in areas such as science, engineering, knowledge engineering, finance, or IT services.

The following roles could be interested:

- Engineers
- Scientists
- Professional research managers
- Chief technical officers
- Chief information officers
- Organisational change practitioners and managers
- Business change practitioners and managers
- Service architects and managers
- Program and planning managers
- Service provider portfolio strategists / leads
- Process architects and managers
- Business strategists and consultants
- Web page developers

## Course Format and Duration

Candidates can choose to study for this certificate from one of two ways: by either attending a training course provided by a BCS Accredited Training Organisation, or by self-study.

BCS recommends that for full coverage of the syllabus to be achieved, training courses leading to the certificate should normally run for a minimum 6 hours over 1 day.

**Candidates should spend about 40 hours on self-study with no prior knowledge.**

## Examination Format and Duration

|                    |   |
|--------------------|---|
| <b>Type</b>        | 20 Multiple choice questions                      |
| <b>Duration</b>    | 30 Minutes  |
| <b>Supervised</b>  | Yes   |
| <b>Open Book</b>   | No  |
| <b>Pass Mark</b>   | 13/20   |
| <b>Calculators</b> | No calculators nor mobile technology is permitted |
| <b>Delivery</b>    | Paper based examination                           |

## Eligibility for the Examination

There are no specific pre-requisites for the entry to the examination, although a good knowledge of computers and a basic understanding of data using computers (e.g. spreadsheets) is highly recommended.

## Additional Time

### For Candidates Requiring Reasonable Adjustments Due to a Disability

Please refer to the [reasonable adjustments policy](#) for information on how and when to apply.

### For Candidates Whose Language is Not the Language of the Examination

If the examination is taken in a language that is not the candidate's native/official language, then they are entitled to:

- 25% extra time.
- Use their own **paper** language dictionary (whose purpose is translation between the examination language and another national language) during the examination. Electronic versions of dictionaries will **not** be allowed into the examination room.

## Guidelines for Accredited Training Organisations

Each major subject heading in this syllabus is assigned an allocated percentage of study time.

The purpose of this is:

- 1) Guidance on the proportion of time allocated to each section of an accredited course.
- 2) Guidance on the proportion of questions in the exam.

Courses do not have to follow the same order as the syllabus and additional exercises may be included, if they add value to the training course.

## Exam Weighting

| Syllabus Area  | Target Number of Questions |
|--|----------------------------|
| Artificial and Human Intelligence: An Introduction and History     | 25% - 5 Questions – K1     |
| Examples of AI - Benefits, Challenges and Risks                    | 30% - 6 Questions – K2     |
| An introduction to Machine Learning                                | 35% - 7 Questions – K1     |
| The Future of Artificial Intelligence – Human and Machine Together | 10% - 2 Questions – K1     |

## Trainer Criteria

The following criterion apply:

- Hold an Essentials Certificate in Artificial Intelligence;
- Have 3 years' experience in related subject (including, but not limited to: data science, high performance computing, scientific computing, data analytics, statistics, mathematics);
- Have taught courses professionally.

## Classroom Size

Trainers may instruct up to 15 candidates.

## Invigilator to Candidate Ratio During Examination

Up to 25 candidates per invigilator.

# Syllabus

## Learning Objectives

### 1. Artificial and Human Intelligence: An Introduction and History (25%)

Candidates will be able to:

- 1.1 Recall the general definition of human and Artificial Intelligence (AI);
- 1.2 Describe 'learning from experience' and how it relates to Machine Learning (ML) (Tom Mitchell's explicit definition);
- 1.3 Understand that ML is a significant contribution to the growth of Artificial Intelligence;
- 1.4 Describe how AI is part of '*Universal Design*,' and '*The Fourth Industrial Revolution*'.

### 2. Examples of AI: Benefits, Challenges and Risks (30%)

Candidates will be able to:

- 2.1 Explain the benefits of Artificial Intelligence, and
  - 2.1.1 list advantages of machine and human and machine systems;
- 2.2 Describe the challenges of Artificial Intelligence, and give:
  - 2.2.1 general examples of the limitations of AI compared to human systems,
  - 2.2.2 general ethical challenges AI raises.
- 2.3 Demonstrate understanding of the risks of Artificial Intelligence, and
  - 2.3.1 give at least one a general example of the risks of AI;
- 2.4 Identify a typical funding source for AI projects;
- 2.5 List opportunities for AI.

### 3. An introduction to Machine Learning (35%)

Candidates will be able to:

- 3.1 Demonstrate understanding of the AI intelligent agent description, and:
  - 3.1.1 identify the differences with Machine Learning (ML), and:
  - 3.1.2 list the four rational agent dependencies,
  - 3.1.3 describe agents in terms of performance measure, environment, actuators and sensors,



- 3.1.4 describe four types of agent: reflex, model-based reflex, goal-based and utility-based.
- 3.2 Give typical examples of Machine Learning in the following contexts:
  - 3.2.1 business,
  - 3.2.2 social (media, entertainment),
  - 3.3.3 science.
- 3.3 Recall which typical, narrow AI capability is useful in ML and AI agents' functionality;
- 3.4 Describe and give examples of the following forms of ML:
  - 3.4.1 supervised,
  - 3.4.2 unsupervised,
  - 3.4.3 reinforcement.
- 3.5 Describe the basic schematic of a neural network.

#### **4. The Future of Artificial Intelligence – Human and Machine Together (10%)**

Candidates will be able to:

- 4.1 Demonstrate an understanding that Artificial Intelligence (in particular, Machine Learning) will drive humans and machines to work together;
- 4.2 List future directions of humans and machines working together.

## Recommended Reading List

### Artificial Intelligence and Consciousness

**Title** Artificial Intelligence, A Modern Approach, 3rd Edition  
**Author** Stuart Russell and Peter Norvig,  
**Publication Date** 2016,  
**ISBN 10** 1292153962

**Title** The Cambridge Handbook of Artificial Intelligence,  
**Author** Keith Frankish and William Ramsey  
**Publication Date** 2014  
**ISBN** 978-0-521-69191-8

**Title** The Conscious Mind  
**Author** David Chalmers  
**Publication Date** 1996  
**ISBN** 978-0-19-511789-9

**Title** Life 3.0  
**Author** Max Tegmark  
**Publisher** Penguin Books  
**Publication Date** 2017  
**ISBN** 978-0-141-98180-2

**Title** Artificial Intelligence Foundations (learning from experience)  
**Author** Andrew Lowe and Steve Lawless  
**Publisher** BCS  
**Publication Date** 2021  
**ISBN** 9781780175300

### Machine Learning

**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,  
**Publication Date** 2017  
**ISBN** 1549617214.

### High Level / Management Consultant View of Machine Learning

**Title** The Fourth Industrial Revolution  
**Author** Klaus Schwab  
**Publisher** Penguin Random House  
**Publication Date** 2016  
**ISBN** 978-0-241-30075-6

**Title** Human + Machine - Reimagining Work in the Age of AI  
**Author** Paul R. Daugherty and H. James Wilson  
**Publisher** Harvard Business Review Press  
**Publication Date** 2018  
**ISBN** 1633693869.

### **High Level / Research and Political View of Machine Learning**

<https://royalsociety.org/topics-policy/projects/machine-learning/>

### **Professional Development of Machine Learning Algorithms and Planning**

**Title** Hands-On Machine Learning with -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 – A Probabilistic Perspective  
**Author** Kevin P. Murphy  
**Publisher** MIT  
**Publication Date** 2012  
**ISBN-10** 0262018020

### **Additional Reading:**

**Title** The Singularity is Near  
**Author** Ray Kurzweil  
**Publisher** Duckworth Overlook  
**Publication Date** 2005  
**ISBN** 978-0715635612

**Title** The Mythical Man Month  
**Author** Frederick P. Brooks, JR.,  
**Publisher** Addison Wesley  
**Publication Date** 1995  
**ISBN** 0-201-83595-9

**Title** Artificial Intelligence: 101 Things You Must Know Today About Our Future  
**Author** Lasse Rouhiainen  
**Publisher** CreateSpace Independent Publishing Platform  
**Publication Date** 2018  
**ISBN** 1982048808.



## Abbreviations

| Abbreviation | Meaning                             |
|--------------|-------------------------------------|
| AI           | Artificial Intelligence             |
| IoT          | Internet of Things                  |
| ANN          | Artificial Neural Network           |
| NN           | Neural Network                      |
| CNN          | Convolution Neural Network          |
| ML           | Machine Learning                    |
| OCR          | Optical Character Recognition       |
| NLP          | Natural Language Processing         |
| DL           | Deep Learning                       |
| DNN          | Deep Neural Networks                |
| AGI          | Artificial General Intelligent      |
| CPU          | Central Processing Unit             |
| GPU          | Graphical Processing Unit           |
| RPA          | Robotic Process Automation          |
| CART         | Classification and Regression Trees |
| IT           | Information Technology              |
| IQ           | Intelligence Quotient               |
| EQ           | Emotional Quotient                  |

## Glossary of Terms

| Term                         | Description or Definition   |
|------------------------------|---|
| Activation Function          | The activation function defines the output of a node given an input or set of inputs.   |
| Agent Modelling              | An intelligent agent (IA) is autonomous, observes through sensors and acts on its environment using actuators.                                  |
| Algorithm                    | An algorithm is an unambiguous specification of how to solve a class of problems.   |
| Artificial Intelligence (AI) | A branch of computer science dealing with the simulation of intelligent behaviour in computers.   |
| Automation                   | Automatically controlled operation of an apparatus, process, or system by mechanical or electronic devices that take the place of human labour. |
| Autonomous                   | Undertaken or carried on without outside control  |
| Axon                         | An axon is a long, slender projection of a nerve cell, or neuron, that typically conducts electrical impulses.                                  |
| Axon Terminals               | Axon terminals are terminations of the telodendria (branches) of an axon.   |
| Back-propagation             | A method used in artificial neural networks to calculate a gradient required in the calculation of the weights to be used in the network.       |
| Bayesian Network             | A Bayesian network or belief network is a probabilistic graphical model that represents a set of variables and their conditional dependencies.  |
| Bias                         | Deviation of the expected value of a statistical estimate from the quantity it estimates.   |

| Term  | Description or Definition  |
|---|--|
| Big Data  | Big data is data sets that are so big and complex that traditional data-processing application software are inadequate to deal with them.  |
| Boosting  | Boosting is an ensemble meta-algorithm for reducing bias, and also variance in supervised learning and family algorithms that convert weak learners to strong ones.  |
| Bootstrap Aggregating – Bagging                   | Bootstrap aggregating, is an ensemble meta-algorithm used in statistical classification and regression.  |
| Chatbot   | A chatbot is an artificial intelligence program that conducts a conversation via auditory or textual methods.  |
| Classification                                    | Classification is the problem of identifying to which of a set of classes a new observation belongs.   |
| Clustering  | Clustering groups a set of objects in such a way that objects in the same group are more similar to each other than to those in other groups.  |
| Cognitive Simulation                              | Cognitive simulation uses computers that test how the human mind works.  |
| Combinatorial Complexity                          | Is the exponential growth in computer power required to solve a problem that has many combinations with increasing complexity.   |
| Combinatorial Explosion                           | A combinatorial explosion is the rapid growth of the complexity of a problem due to the combinations of the problem's input parameters.  |
| Connectionist                                     | Cognitive science that hopes to explain intellectual abilities using artificial neural networks.   |
| Data Analytics                                    | The discovery, interpretation, and communication of meaningful patterns in data.   |
| Data Cleaning                                     | Data cleaning detects and corrects ( or removes ) corrupt or inaccurate records from a record set, table, or database and refers to identifying incomplete, incorrect, inaccurate or irrelevant parts of the data and then replacing, modifying, or deleting the dirty or coarse data. |
| Data Mining                                       | The process of discovering patterns in large data sets.  |
| Data Science                                      | Data science uses scientific methods, processes, algorithms and systems to understand data.  |
| Data Scrubbing                                    | See data cleaning.   |
| Decisions Trees                                   | A decision tree is a decision support tool that uses a tree-like graph or model of decisions and their possible consequences.  |
| Deep Learning                                     | Deep learning is a class of algorithms that use a cascade of multiple layers for feature extraction and transformation. Each successive layer uses the output from the previous layer as input.  |
| Dendrites   | Dendrites are branched extensions of a nerve cell that propagate the electrochemical stimulation.  |
| Edges   | Edges are the machine learning name for the brain's axons  |
| Emotional Intelligence or Emotional Quotient (EQ) | The understanding of our emotions and the emotions of others.  |
| Ensemble  | Ensemble methods use multiple learning algorithms to obtain better predictive performance than could be obtained from any of the constituent learning algorithms alone.  |
| Expert Systems                                    | An expert system is a computer system that emulates the decision-making ability of a human expert.   |
| Feedforward Neural Network                        | A feedforward neural network is an artificial neural network wherein connections between the nodes do not form a cycle.  |
| Functionality                                     | The tasks that a computer software program can do  |
| Genetic Algorithms                                | a genetic algorithm (GA) is an algorithm inspired by the process of natural selection.   |

| Term   | Description or Definition  |
|--|--|
| Hardware                                     | Hardware are the physical parts or components of a computer.   |
| Heuristic                                    | Heuristic is a strategy derived from previous experiences with similar problems.   |
| High Performance Computing – Super Computing | HPC or Supercomputing is a computer with a high level of performance compared to a general-purpose computer.   |
| Hyper-parameters                             | A hyperparameter is a parameter whose value is set before the learning process begins.   |
| Inductive Reasoning                          | Inductive reasoning makes broad generalisations from specific observations.  |
| Internet of Things (IoT)                     | The Internet of Things (IoT) is the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these things to connect and exchange data. |
| Intelligent Quotient (IQ)                    | Is a standard test of intelligence.  |
| k-Means                                      | k-Means is a clustering algorithm that partitions observations into $k$ clusters, where each observation belongs to the cluster with the nearest mean, serving as a prototype of the cluster.  |
| k-Nearest Neighbours                         | The simplest clustering algorithm used to classify new data points based on the relationship to nearby data points.  |
| Layers                                       | Neural networks are organised into layers and a layer is a set of interconnected nodes.  |
| Linear Algebra                               | Linear algebra is the branch of mathematics concerning linear equations and functions and their representations through matrices and vector spaces.  |
| Logistic Regression                          | Logistic Regression is used in binary classification to predict two discrete classes.  |
| Machine Learning (ML)                        | Machine learning is a subset of artificial intelligence in the field of computer science that gives computers the ability to learn from data.  |
| Model Optimisation                           | The improvement of the output of a machine learning algorithm (e.g. adjusting hyper parameters).   |
| Natural Language Processing (NLP)            | Natural Language Processing (NLP) is an area of artificial intelligence concerned with the interactions between computers and human (natural) languages, and how these happen.   |
| Natural Language Understanding (NLU)         | Natural Language Understanding is the term used to describe machine reading comprehension.   |
| Nearest Neighbour Algorithm                  | The Nearest Neighbour Algorithm was one of the first algorithms used to determine a solution to the travelling salesman problem.   |
| Neural Network (NN)                          | A Machine Learning Algorithm that is based on a mathematical model of the biological brain.  |
| Nodes  | Nodes represent neurons (biological brain) and are interconnected to form a neural network.  |
| One-hot Encoding                             | Transforms text-based features into a numerical form, e.g. false is given the number zero and true is given the number 1.  |
| Ontology                                     | Ontology is the philosophical study of the nature of being, becoming, existence, or reality, as well as the basic categories of being and their relations.   |
| Optical Character Recognition (OCR)          | Optical Character Recognition is the conversion of images of typed, handwritten or printed text into machine-encoded text.   |
| Over-fitting or Over-training                | Overfitting is a machine learning model that is too complex, has high variance and low bias. It is the opposite of Under-fitting or Under-training.  |
| Probabilistic Inference                      | Probabilistic Inference uses simple statistical data to build nets for simulation and models.  |

| Term   | Description or Definition  |
|--|--|
| Probability                                  | Probability is the measure of the likelihood that an event will occur.   |
| Pruning                                      | Pruning reduces the size of decision trees.  |
| Python                                       | A programming language popular in machine learning.  |
| Random Decision Forests                      | Random Decision Forests are an ensemble learning method for classification, regression and other tasks.  |
| Random Forests                               | Random Forests are an ensemble learning method for classification, regression and other tasks, that operate by constructing a multitude of decision trees at training time.  |
| Regression Analysis                          | In machine learning, regression analysis is a simple, supervised learning technique used to find a trendline to describe the data.   |
| Reinforcement Machine Learning (RL)          | Reinforcement Learning (RL) uses software agents that take actions in an environment to maximise some notion of cumulative reward.   |
| Robotics                                     | Robotics deals with the design, construction, operation, and use of robots, as well as computer systems for their control, sensory feedback, and information processing.   |
| Robotic Process Automation (RPA)             | Robotic Process Automation is a business process automation technology based on the notion of <i>software robots</i> or artificial intelligence workers.   |
| Scripting                                    | Scripting are programs written for a special run-time environment that automate the execution of tasks that could alternatively be executed one-by-one by a human operator.  |
| Search                                       | The use of machine learning in search problems, e.g. shortest path.  |
| Semi-supervised Machine Learning             | Machine learning that uses labelled and unlabelled data for training.  |
| Sigmoid Function                             | A sigmoid function is a mathematical function having a characteristic "S"-shaped curve or sigmoid curve.   |
| Software                                     | Software is a generic term that refers to a collection of data and computer instructions that tell the computer how to work.   |
| Software Robots                              | A software robot replaces a function that a human would otherwise do.  |
| Strong AI or Artificial General Intelligence | Strong AI's goal is the development of artificial intelligence to the point where the machine's intellectual capability is functionally equal to a human's.  |
| Supervised Machine Learning                  | Supervised Machine Learning is the task of learning a function that maps an input to an output based on example input-output pairs.  |
| Support Vector Machine                       | A support vector machine constructs a hyperplane or set of hyperplanes in a high- or infinite- dimensional space, which can be used for classification, regression, or other tasks like outlier detection.                 |
| Swarm Intelligence (SI)                      | Swarm Intelligence is the collective behaviour of decentralised, self-organised systems, natural or artificial   |
| Symbolic                                     | Symbolic artificial intelligence is the term for the collection of all methods in artificial intelligence research that are based on high-level "symbolic" (human-readable) representations of problems, logic and search. |
| System                                       | A regularly interacting or interdependent group of items forming a unified whole.  |
| The Fourth Industrial Revolution             | The Fourth Industrial Revolution builds on the Digital Revolution, representing new ways in which technology becomes embedded within societies and even the human body.  |
| Turing Machine                               | A Turing machine is a mathematical model of computation.   |



| Term                          | Description or Definition   |
|-------------------------------|---|
| Unsupervised Machine Learning | Unsupervised Machine Learning infers a function that describes the structure of unlabelled data.  |
| Underfitting                  | Underfitting is when the machine learning model has low variance and high bias. It is the opposite of Overfitting or Overtraining.  |
| Universal Design              | Universal Design (close relation to inclusive design) refers to broad-spectrum ideas meant to produce buildings, products and environments that are inherently accessible to older people, people without disabilities, and people with disabilities. |
| Validation Data               | A set of data used to test the output of a machine learning model that is not used to train the model.  |
| Variance                      | Variance is the expectation of the squared deviation of a random variable from its mean.  |
| Visualisation                 | Visualisation is any technique for creating images, diagrams, or animations to communicate a message.   |
| Weak AI or Narrow AI          | Weak artificial intelligence (weak AI), also known as Narrow AI, is artificial intelligence that is focused on one narrow task. It is the contrast of Strong AI.  |
| Weights                       | A weight function is a mathematical device used when performing a sum, integral, or average to give some elements more "weight" or influence on the result than other elements in the same set.   |