

ARTIFICIAL

INTELLIGENCE

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# Artificial Intelligence

[As Per the New Syllabus 2018-19 of Mumbai University  
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## DEDICATION

First and foremost, I would like to thank God. In the process of putting this book together, I realized how true this gift of writing is for me. You gave me the power to believe in my passion and pursue my dreams.

I would like to dedicate this book to **my Mom (Kavita S. Bajaj)** and **my Son (Chirag Gurbani)**. There is a reason my mom being whole and sole support towards my dedication, she is such an identity who makes me rise each and every moment.

Finally, I would like to take this opportunity to express my deep sense of gratitude for lifetime to a special person **Mr. S.K. Srivastava of Himalaya Publishing House Pvt. Ltd.** for his valuable guidance, constant encouragement, immense motivation and new positivity in my life that has appeared as a gift which is sent from God and he left figureprints of grace in my life. Really, I am sincerely grateful to him for sharing his truthful and illuminating views which has motivated throughout to write such fantastic content. Last but not the least, I would like to thank whole Himalaya Production Team.

*– Prof. Kiran Gurbani*

This book is dedicated to all those who believed in me and gave me enough motivation to work day and night for the best outcome. By the grace of almighty. I would like to thank my parents and sister Diana for their consistent support and love.

I would like to thank **Prof. Mahendra Kanojia** who initiated the knowledge and interest of Artificial Intelligence in me. I would also like to thank **Dr. Ravi Gomatham** sir for blessing me with the correct knowledge of AI and giving me his time and the one who made it possible for me **Ms. Kanwaljeet Saluja** from Institute of Semantic Sciences and Technology.

I am not all correct but have tried to contribute a bit in this book with whatever possible knowledge I have received from all the sources almighty could provide me.

*– Sohrab Ardeshar Vakharia*

“No man succeeds without a good woman behind him. Wife or mother, if it is both, he is twice blessed indeed”. I am truly twice blessed. So, I would like to take this opportunity to thank and dedicate my small piece of work to Prof. **Kiran Gurbani** and my wife “**Poonam Jaiswal**”. You both are really a god’s blessing for me.

*– Prof. Ravindra Jaiswal*

## **PREFACE**

It is a great pleasure for presenting First Edition of Revised syllabus of the Book “*Artificial Intelligence*” to the students of B.Sc. (IT) This book is written to cover all the topics of syllabus prescribed by the University of Mumbai for T.Y.B.Sc. (IT).

Welcome to the wumpus world. A new fresh world of Artificial Intelligence. Where intelligence is not limited to humans anymore. It is nurtured in the machines and their DNA. The book which we are presenting will help clearing the basics of AI and shall be helpful in building the fundamentals of AI and future. Artificial Intelligence has its roots in several fields ranging from our daily lives to rocket science. We will get to learn those fundamentals of AI on which entire history is built.

The concept and theory of each topic is followed by the theoretical explanation, some self-assessment questions and all practical solutions of Artificial Intelligence, according to University pattern, are provided at the end of this book. Efforts have been made to make the text easy to read and understand. In this book, we have covered all types of programs expected by University of Mumbai in practical examination. At the end of this book, sample question paper is given for the student practice.

We have tried our level best to give everything in this book in proper manner. Still few points from book may be explained in better way than presently are there in the book.

Constructive suggestions and comments from the users will be sincerely appreciated. We would appreciate hearing from you about any textual errors or omissions which you identify. If you would like to suggest improvements or contribute in any way, we would be glad to hear from you.

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Last but not the least, we would like to give big lifetime thanks to Mr. S.K. Srivastava (Himalaya Publishing House Pvt. Ltd.) for providing an environment which stimulates new thinking and innovations and his support, motivation, guidance, cooperation and encouragement to write this book. We are very grateful for his support and thank him for his true blessings.

Hope the readers would enjoy the learning process from this book.

**Authors**

# SYLLABUS

Sr. No.	Modules/Units
<b>I</b>	<p><b>Introduction</b> What is Artificial Intelligence? Foundations of AI, History, The State-of-Art AI Today</p> <p><b>Intelligent Agent</b> Agents and Environments, Good Behaviour, Nature of Environments, The Structure of Agents</p>
<b>II</b>	<p><b>Solving Problems by Searching</b> Problem Solving Agents, Examples Problems, Searching for Solutions, Uninformed Search, informed Search, Strategies, Heuristic Function</p> <p><b>Beyond Classical Search</b> Local Search Algorithms, Searching with Non-deterministic Action, Searching with Partial Observations, Online Search Agents and Unknown Environments</p>
<b>III</b>	<p><b>Adversarial Search</b> Games, Optimal Decisions in Games, Alpha-Beta Pruning, Stochastic Games, Partially Observable Games, State-of-the-Art Game Programs</p> <p><b>Logical Agents</b> Knowledge-based Agents, The Wumpus World, Logic, Propositional Logic, Propositional Theorem Proving, Effective Propositional Model Checking, Agent Based on Propositional Logic</p>
<b>IV</b>	<p><b>First Order Logic</b> Syntax and Semantics, Using First Order Logic, Knowledge Engineering in First Order Logic</p> <p><b>Inference in First Order Logic</b> Propositional vs. First Order, Unification and Lifting, Forward and Backward Chaining, Resolution</p>
<b>V</b>	<p><b>Planning</b> Definition of Classical Planning, Algorithms for Planning as State Space Search, Planning Graphs, Other Classical Planning Approaches, Analysis of Planning Approaches, Time, Schedules and Resources, Hierarchical Planning, Planning and Acting in Non-deterministic Domains, Multi-agent Planning</p> <p><b>Knowledge Representation</b> Categories and Objects, Events, Mental Events and Objects, Reasoning System for Categories, Reasoning with Default Information, The Internet Shopping World</p>

## QUESTION PAPER PATTERN

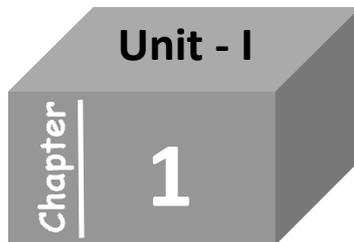
**Maximum Marks: 75**

**Duration: 2 ½ Hours**

- Q.1. Attempt any **three** of the following: (15)
- (a)
  - (b)
  - (c)
  - (d)
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- Q.2. Attempt any **three** of the following: (15)
- (a)
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- Q.3. Attempt any **three** of the following: (15)
- (a)
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- Q.4. Attempt any **three** of the following: (15)
- (a)
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- Q.5. Attempt any **three** of the following: (15)
- (a)
  - (b)
  - (c)
  - (d)
  - (e)
  - (f)

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# Introduction

## Chapter Outline

- 1.1 *Introduction*
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## 1.1 Introduction

- ▶▶ In 1956 at The Dartmouth Conference, an American computer scientist, “John McCarthy” coined a term ARTIFICIAL INTELLIGENCE.
- ▶▶ John McCarthy also refer as father of Artificial Intelligence, he emphasized that “The science and engineering of making intelligent machines, especially intelligent computer programs”.
- ▶▶ AI is the simulation of human intelligence processes by machines, especially computer systems.
- ▶▶ Intelligence is a property/ability attributed to people, such as to know, to think, to talk, to learn, to understand.
- ▶▶ Artificial Intelligence is a way of making a computer, a computer-controlled robot, or a software think intelligently, in the similar manner the intelligent humans think.
- ▶▶ AI is accomplished by studying how human brain thinks, and how humans learn, decide, and work while trying to solve a problem, and then using the outcomes of this study as a basis of developing intelligent software and systems.
- ▶▶ AI is the processes include learning of the acquisition of information and rules for using the information, reasoning and using the rules to reach approximate or definite conclusions and self-correction.

- ▶ The term artificial intelligence covers a lot of disparate problem areas, united mainly by the fact that they involve complex inputs and outputs that are difficult to compute.
- ▶ One of the most interesting such areas is sensor-controlled behavior, in which a machine acts in the real world using information gathered from sensors.
- ▶ Artificial intelligence (AI) makes it possible for machines to learn from experience, adjust to new inputs and perform human-like tasks.

### 1.1.1 What is Artificial Intelligence?

1. Artificial Intelligence (AI) is a general term that implies the use of a computer to model and/or replicate intelligent behavior.
2. Research in AI focuses on the development and analysis of algorithms that learn and/or perform intelligent behavior with minimal human intervention.
3. Artificial intelligence (AI) is the ability of a machine or a computer program to think and learn.
4. The concept of AI is based on the idea of building machines capable of thinking, acting, and learning like humans.
5. All but the simplest human behavior is describe as intelligence, while even the most complicated animal behavior is never taken as an indication of intelligence.
6. Psychologists generally do not characterize human intelligence by just one trait but by the combination of many diverse abilities.
7. AI has focused chiefly on the following components of intelligence.

### 1.1.2 What is Intelligence?

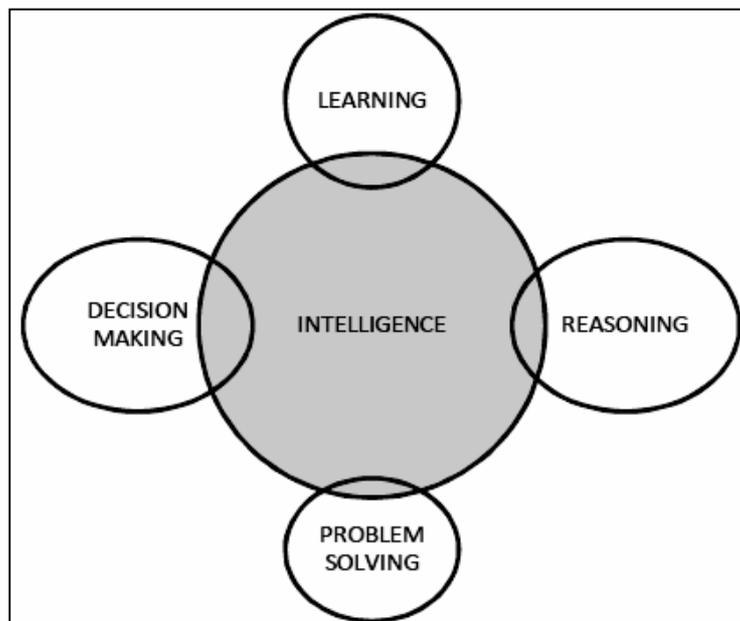


Fig. 1.1

### **Learning**

1. There are a number of different forms of learning as applied to artificial intelligence.
2. The simplest is learning by trial and error. For example, a simple computer program for solving mate-in-one chess problems might try moves at random until mate is found.
3. The program might then store the solution with the position so that the next time the computer encountered the same position it would recall the solution.

### **Reasoning**

1. To reason is to draw inferences appropriate to the situation. Inferences are classified as either deductive or inductive.
2. Reasoning is what we do when we take information that we are given, compare it to what we already know, and then come up with a conclusion.
3. Reasoning skills often happen subconsciously and within seconds.
4. However, sometimes we need to think things through to reach a conclusion when we are presented with a tough question or situation.

### **Decision Making**

1. Decision making is the process of making choices by identifying a decision, gathering information, and assessing alternative resolutions.
2. Using a step-by-step decision-making process can help you make more deliberate, thoughtful decisions by organizing relevant information and defining alternatives.
3. This approach increases the chances that you will choose the most satisfying alternative possible.

### **Problem Solving**

1. Problem solving, particularly in artificial intelligence, may be characterized as a systematic search through a range of possible actions in order to reach some predefined goal or solution.
2. Problem-solving methods divide into special purpose and general purpose.
3. A special-purpose method is tailor-made for a particular problem and often exploits very specific features of the situation in which the problem is embedded.
4. In contrast, a general-purpose method is applicable to a wide variety of problems. One general-purpose technique used in AI is means-end analysis—a step-by-step, or incremental.

## **1.1.3 Some of the Common definitions for Artificial Intelligence**

*“Artificial Intelligence is a study of complex information processing problems that often have their roots in some aspect of biological information processing. The goal of the subject is to identify solvable and interesting information processing problems, and solve them.”* - **David Marr.**

*“Artificial Intelligence is the design, study and construction of computer programs that behave intelligently.”* - **Tom Dean.**

*“Artificial Intelligence is the enterprise of constructing a physical symbol system that can reliably pass the Turing test.”* - **Matt Ginsberg.**

*“Artificial Intelligence is an interdisciplinary concept that studies the possibility of creating machines capable of interacting with their environment and acting upon the received data in the a manner considered intelligent.”*

*“Artificial Intelligence is a latest field aiming at developing techniques and tools for solving problems that people at good at.”*

## 1.2 Application of AI

### 1. Game playing:

- (a) You can buy machines that can play master level chess for a few hundred dollars.
- (b) There is some AI in them, but they play well against people mainly through brute force computation--looking at hundreds of thousands of positions.
- (c) To beat a world champion by brute force and known reliable heuristics requires being able to look at 200 million positions per second

### 2. Speech recognition:

- (a) In the 1990s, computer speech recognition reached a practical level for limited purposes.
- (b) Thus United Airlines has replaced its keyboard tree for flight information by a system using speech recognition of flight numbers and city names.
- (c) It is quite convenient. On the other hand, while it is possible to instruct some computers using speech, most users have gone back to the keyboard and the mouse as still more convenient.

### 3. Expert systems:

- (a) A “knowledge engineer” interviews experts in a certain domain and tries to embody their knowledge in a computer program for carrying out some task.
- (b) How well this works depends on whether the intellectual mechanisms required for the task are within the present state of AI.
- (c) When this turned out not to be so, there were many disappointing results.

### 4. Computer vision:

- (a) The world is made out of three-dimensional items, yet the contributions to the human eye and PCs’ TV cameras are two dimensional.
- (b) Some valuable projects can work exclusively in two measurements, yet full PC vision requires incomplete three-dimensional data that isn’t only an arrangement of two-dimensional perspectives.

### 5. Heuristic classification:

- (a) One of the most feasible kinds of expert system given the present knowledge of AI is to put some information in one of a fixed set of categories using several sources of information.
- (b) *An example* is advising whether to accept a proposed credit card purchase. Information is available about the owner of the credit card, his record of payment and also about the item he is buying and about the establishment from which he is buying it.

**6. Robotics:**

- (a) A robot is an electromechanical gadget that can be customized to aroma manual assignments.
- (b) The apply autonomy ventures affiliation formally characterizes to move a Robot as a “Programmable multi-utilitarian controller intended to move material, parts, instruments, or concentrated gadgets through factor modified movements for the execution of assortment of assignments”.

**7. Automatic Programming:**

- (a) The objective of programmed writing computer programs is to make exceptional projects that go about as canny “Apparatuses” to help software engineers and assist each period of the programming procedure.
- (b) A definitive point of programmed writing computer programs is a PC framework that could create programs without anyone else’s input, in light of an in concurring with the determinations of the program designer.

**8. Medicinal services:**

- (a) The greatest wagers are on enhancing quiet results and decreasing expenses.
- (b) Organizations are applying machine figuring out how to improve and quicker determinations than people.
- (c) Extraordinary compared to other known social insurance advancements in.
- (d) It comprehends normal dialect and is fit for reacting to questions asked of it.
- (e) The framework mines persistent information and other accessible information sources to shape a theory, which is at that point present with a certainty scoring pattern.

**9. Business:**

- (a) Mechanical process mechanization is being connected to exceptionally monotonous undertakings typically performed by people.
- (b) Machine learning calculations are being incorporated into investigation and CRM stages to reveal data on the best way to better serve clients.

**10. Education:**

- (a) AI can mechanize reviewing, giving instructor’s additional time.
- (b) AI can evaluate understudies and adjust to their requirements, helping them work at their own particular pace.
- (c) AI coaches can give extra help to understudies, guaranteeing they remain on track.
- (d) AI could change where and how understudies learn, maybe notwithstanding supplanting a few instructors.

**11. Finance:**

- (a) AI connected to individual back applications, for example, Mint or Turbo Tax, is overturning money related organizations.
- (b) Applications, for example, these could gather individual information and give monetary guidance.
- (c) Different projects, IBM Watson being one, have been connected to the way toward purchasing a home.

**12. Law:**

- (a) The disclosure procedure, filtering through of archives, in law is regularly overpowering for people.
- (b) Robotizing this procedure is a superior utilization of time and a more productive process.
- (c) New businesses are additionally constructing inquiry and-answer PC partners that can filter customized to-answer inquiries by analyzing the scientific categorization and cosmology related with a database.

**13. Manufacturing:**

- (a) This is a zone that has been at the bleeding edge of joining robots into the work process.
- (b) Modern robots used to perform single assignments and were isolated from human specialists, yet as the innovation propelled that changed.

## 1.3 Foundations of AI

*Foundations of Artificial Intelligence* does not present a coherent set of “foundations of AI”: instead, it presents a diverse collection of opinions regarding different aspects of the discipline

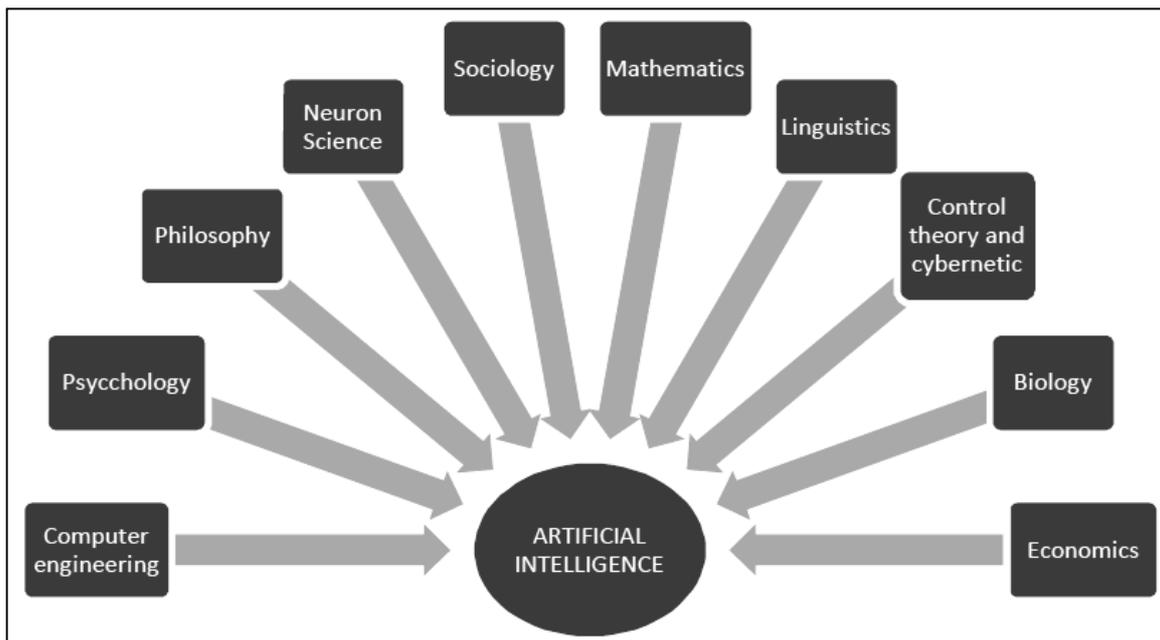


Fig. 1.2

### Computer Engineering

1. Artificial intelligence deals with “making the machine reason and learn” - the reasoning part is incorporated as ‘automatic code generation-like mechanism’ and the learn part is incorporated as allowing the adjustment of the ‘code-parameters’ by looking at the data.
2. Both of these require strong programming knowledge and skill. So, as a computer engineer, one would have an edge over others.

3. For artificial intelligence to succeed, we need two things; intelligence and artifact. The computer has been the artifact of the choice.

### ***Psychology***

1. Psychology tries to answer the following question how do humans and animals think and act.
2. Modern science proves that computer models could be used to address the psychology of memory, language and logical thinking respectively.
3. It is now a common view among psychologists that, “a cognitive theory should be like a computer program”.

### ***Philosophy***

Artificial Intelligence takes the following ideas from philosophy.

1. **Can formal rules be used to draw valid conclusion:** An informal system of syllogisms for proper reasoning, which in principle allowed one to generate conclusions mechanically given initial premises.
2. **How does the mind arises from a physical brain?:** It is one thing to say that mind operates, at least in part, according to logical rules, and to build physical system that emulate some of those rules, **but** it’s another thing to say that mind itself is such a physical system.
3. **Where does knowledge come from?:** Given a physical mind that manipulate knowledge, the next problem is to establish the source of knowledge.
4. **How does knowledge lead to action?:** Philosophy tries to answer the connection between knowledge and action. This question is vital to AI because intelligence requires action as well as reasoning.

### ***Neuroscience***

1. Neuroscience is the study of the nervous system, particularly the brain.
2. This study of how brain process information directly help in the development of artificial intelligence.

### ***Computational Sociology***

1. It is a branch of sociology that uses computationally intensive methods to analyze and model social phenomena.
2. Using computer simulations, artificial intelligence, complex statistical methods, and analytic approaches like social network analysis, computational sociology develops and tests theories of complex social processes through bottom-up modeling of social interactions.
3. It involves the understanding of social agents, the interaction among these agents, and the effect of these interactions on the social aggregate.

### ***Mathematics***

Philosophers staked out some of the fundamental ideas of AI, but the leap to formal science required a level of mathematical formalization in three fundamental areas:

1. What are the formal rules to draw valid conclusion?
2. What can be computed (computational complexity)?
3. How do we reason with uncertain information?

### ***Linguistics***

1. Language is directly related to thought.
2. Modern linguistics and AI, were born at about the same time and grew up together, intersecting in a hybrid field called Computational Linguistics or Natural Language Processing.

### ***Control Theory and Cybernetics***

1. Control theory and cybernetics deals with the self controlling machine.
2. Modern control theory has its goal to design the system that maximize an objective function over time.
3. This roughly match the AI view: designing system that behave optimally.

### ***Biology***

1. Bio-inspired AI attempts to synthetically produce systems that exhibit intelligence by taking inspiration from the processes of natural life systems.
2. Examples of bio-inspired artificial intelligence include behavior-based robotics, artificial neural networks, evolutionary algorithms, particle swarm optimization and ant colony optimization.
3. Biology is a branch of science that seeks to determine the laws of nature that lie behind the structure and behavior of living organisms.
4. A biologist will postulate a theory or model in order to explain certain natural phenomena, and will then experimentally verify how well the model predicts what is observed in nature.
5. If the experimental results do not match with what occurs in nature, then in the words of the acclaimed physicist Richard Feynman, “it’s wrong”.
6. Although there is no design constraint in the field of Artificial Intelligence to restrict oneself to applying exactly the same mechanisms to those used by natural life systems, the “wrongness” of the particular model in reproducing natural intelligence can be a useful guide in measuring the success of a bio-inspired AI mode

### ***Economics***

Artificial Intelligence takes the following ideas from economics.

1. **How should we make decisions so as to maximize payoff (utility)?:** Decision Theory, which combines probability theory with utility theory, provides a formal and complete framework for decision made under uncertainty. This is suitable for large “economies” where each agent need pay no attention to the action of other agent as individuals.
2. **How should we do this when others may not go along?:** For small economies, the situation is much more like a **game**: the action of one player can significantly affect the utility of another. Unlike decision theory, game theory does not offer an unambiguous prescription for selecting actions.
3. **How should we do this when the payoff may be far in the future?:** For the most part economist did not address this question. This topic was pursued in the field of operation research.

## 1.4 Brief History of Artificial Intelligence

The history of AI begins with the development of stored-program electronic computers.

1956	<ul style="list-style-type: none"> <li>• John McCarthy coined the term “artificial intelligence” as the topic of the Dartmouth Conference, the first conference devoted to the subject.</li> <li>• Demonstration of the first running AI program, the Logic Theorist (LT) written by Allen Newell, J.C. Shaw and Herbert Simon (Carnegie Institute of Technology, now Carnegie Mellon University).</li> </ul>
1957	<ul style="list-style-type: none"> <li>• The General Problem Solver (GPS) demonstrated by Newell, Shaw &amp; Simon.</li> </ul>
1952-62	<ul style="list-style-type: none"> <li>• Arthur Samuel (IBM) wrote the first game-playing program, for checkers, to achieve sufficient skill to challenge a world champion. Samuel’s machine learning programs were responsible for the high performance of the checkers player.</li> </ul>
1958	<ul style="list-style-type: none"> <li>• John McCarthy (MIT) invented the Lisp language.</li> <li>• Herb Gelernter &amp; Nathan Rochester (IBM) described a theorem prover in geometry that exploits a semantic model of the domain in the form of diagrams of “typical” cases.</li> <li>• Teddington Conference on the Mechanization of Thought Processes was held in the UK and among the papers presented were John McCarthy’s Programs with Common Sense, “Oliver Selfridge’s” “Pandemonium,” and Marvin Minsky’s “Some Methods of Heuristic Programming and Artificial Intelligence.”</li> </ul>
Late 50’s & Early 60’s	<ul style="list-style-type: none"> <li>• Margaret Masterman &amp; colleagues at Cambridge design semantic nets for machine translation. See Themes in the work of Margaret Masterman by Yorick Wilks (1988).</li> </ul>
1961	<ul style="list-style-type: none"> <li>• James Slagle (PhD dissertation, MIT) wrote (in Lisp) the first symbolic integration program, SAINT, which solved calculus problems at the college freshman level.</li> </ul>
1962	<ul style="list-style-type: none"> <li>• First industrial robot company, Unimation, founded.</li> </ul>
1963	<ul style="list-style-type: none"> <li>• Thomas Evans’ program, ANALOGY, written as part of his PhD work at MIT, demonstrated that computers can solve the same analogy problems as are given on IQ tests.</li> <li>• Ivan Sutherland’s MIT dissertation on Sketchpad introduced the idea of interactive graphics into computing.</li> <li>• Edward A. Feigenbaum &amp; Julian Feldman published <i>Computers and Thought</i>,</li> </ul>

1964	<ul style="list-style-type: none"> <li>● Danny Bobrow's dissertation at MIT, shows that computers can understand natural language well enough to solve algebra word problems correctly.</li> <li>● Bert Raphael's MIT dissertation on the SIR program demonstrates the power of a logical representation of knowledge for question-answering systems</li> </ul>
1965	<ul style="list-style-type: none"> <li>● J. Alan Robinson invented a mechanical proof procedure, the Resolution Method, which allowed programs to work efficiently with formal logic as a representation language.</li> <li>● Joseph Weizenbaum built ELIZA, an interactive program that carries on a dialogue in English on any topic. It was a popular toy at AI centers on the ARPAnet when a version that "simulated" the dialogue of a psychotherapist was programmed.</li> </ul>
1966	<ul style="list-style-type: none"> <li>● Ross Quillian demonstrated semantic nets.</li> <li>● First Machine Intelligence workshop at Edinburgh - the first of an influential annual series organized by Donald Michie and others.</li> <li>● Negative report on machine translation kills much work in Natural Language Processing (NLP) for many years.</li> </ul>
1967	<ul style="list-style-type: none"> <li>● Dendral program (Edward Feigenbaum, Joshua Lederberg, Bruce Buchanan, Georgia Sutherland at Stanford) demonstrated to interpret mass spectra on organic chemical compounds. First successful knowledge-based program for scientific reasoning.</li> <li>● Joel Moses demonstrated the power of symbolic reasoning for integration problems in the Macsyma program. First successful knowledge-based program in mathematics.</li> <li>● Richard Greenblatt at MIT built a knowledge-based chess-playing program, MacHack, that was good enough to achieve a class-C rating in tournament play.</li> </ul>
Late 60s	<ul style="list-style-type: none"> <li>● Doug Engelbart invented the mouse at SRI.</li> </ul>
1968	<ul style="list-style-type: none"> <li>● Marvin Minsky &amp; Seymour Papert publish Perceptrons, demonstrating limits of simple neural nets.</li> </ul>
1969	<ul style="list-style-type: none"> <li>● SRI robot, Shakey, demonstrated combining locomotion, perception and problem solving.</li> <li>● Roger Schank (Stanford) defined conceptual dependency model for natural language understanding. Later developed (in PhD dissertations at Yale) for use in story understanding by Robert Wilensky and Wendy Lehnert, and for use in understanding memory by Janet Kolodner.</li> <li>● First International Joint Conference on Artificial Intelligence (IJCAI) held in Washington, D.C.</li> </ul>
1970	<ul style="list-style-type: none"> <li>● Jaime Carbonell (Sr.) developed SCHOLAR, an interactive program for computer-aided instruction based on semantic nets as the representation of knowledge.</li> <li>● Bill Woods described Augmented Transition Networks (ATN's) as a representation for natural language understanding.</li> <li>● Patrick Winston's PhD program, ARCH, at MIT learned concepts from examples in the world of children's blocks.</li> </ul>

<b>Early 70's</b>	<ul style="list-style-type: none"> <li>• Jane Robinson &amp; Don Walker established influential Natural Language Processing group at SRI.</li> </ul>
<b>1971</b>	<ul style="list-style-type: none"> <li>• Terry Winograd's PhD thesis (MIT) demonstrated the ability of computers to understand English sentences in a restricted world of children's blocks, in a coupling of his language understanding program, SHRDLU, with a robot arm that carried out instructions typed in English.</li> </ul>
<b>1972</b>	<ul style="list-style-type: none"> <li>• Prolog developed by Alain Colmerauer.</li> </ul>
<b>1973</b>	<ul style="list-style-type: none"> <li>• The Assembly Robotics group at Edinburgh University builds Freddy, the Famous Scottish Robot, capable of using vision to locate and assemble models.</li> </ul>
<b>1974</b>	<ul style="list-style-type: none"> <li>• Ted Shortliffe's demonstrated the power of rule-based systems for knowledge representation and inference in the domain of medical diagnosis and therapy. Sometimes called the first expert system.</li> <li>• Earl Sacerdoti developed one of the first planning programs, ABSTRIPS, and developed techniques of hierarchical planning.</li> </ul>
<b>1975</b>	<ul style="list-style-type: none"> <li>• Marvin Minsky published his widely-read and influential article on Frames as a representation of knowledge, in which many ideas about schemas and semantic links are brought together.</li> <li>• The Meta-Dendral learning program produced new results in chemistry (some rules of mass spectrometry) the first scientific discoveries by a computer to be published in a refereed journal.</li> </ul>
<b>Mid 70's</b>	<ul style="list-style-type: none"> <li>• Barbara Grosz (SRI) established limits to traditional AI approaches to discourse modeling. Subsequent work by Grosz, Bonnie Webber and Candace Sidner developed the notion of "centering", used in establishing focus of discourse and anaphoric references in NLP.</li> <li>• Alan Kay and Adele Goldberg (Xerox PARC) developed the Smalltalk language, establishing the power of object-oriented programming and of icon-oriented interfaces.</li> <li>• David Marr and MIT colleagues describe the "primal sketch" and its role in visual perception.</li> </ul>
<b>1976</b>	<ul style="list-style-type: none"> <li>• Doug Lenat's AM program demonstrated the discovery model (loosely-guided search for interesting conjectures).</li> <li>• Randall Davis demonstrated the power of meta-level reasoning in his PhD dissertation at Stanford.</li> </ul>
<b>Late 70's</b>	<ul style="list-style-type: none"> <li>• Stanford's SUMEX-AIM resource, headed by Ed Feigenbaum and Joshua Lederberg, demonstrates the power of the ARPAnet for scientific collaboration.</li> </ul>
<b>1978</b>	<ul style="list-style-type: none"> <li>• Tom Mitchell, at Stanford, invented the concept of Version Spaces for describing the search space of a concept formation program.</li> <li>• Herb Simon wins the Nobel Prize in Economics for his theory of bounded rationality, one of the cornerstones of AI known as "satisficing".</li> <li>• The MOLGEN program, written at Stanford by Mark Stefik and Peter Friedland, demonstrated that an object-oriented representation of knowledge can be used to plan gene-cloning experiments.</li> </ul>

1979	<ul style="list-style-type: none"> <li>● Mycin program initially written as Ted Shortliffe's, was demonstrated to perform at the level of experts. Bill VanMelle's PhD dissertation at Stanford demonstrated the generality of MYCIN's representation of knowledge and style of reasoning in his EMYCIN program, the model for many commercial expert system "shells".</li> <li>● Jack Myers and Harry Pople at University of Pittsburgh developed INTERNIST, a knowledge-based medical diagnosis program based on Dr. Myers' clinical knowledge.</li> <li>● Cordell Green, David Barstow, Elaine Kant and others at Stanford demonstrated the CHI system for automatic programming.</li> <li>● The Stanford Cart, built by Hans Moravec, becomes the first computer-controlled, autonomous vehicle when it successfully traverses a chair-filled room and circumnavigates the Stanford AI Lab.</li> <li>● Drew McDermott &amp; Jon Doyle at MIT, and John McCarthy at Stanford begin publishing work on non-monotonic logics and formal aspects of truth maintenance.</li> </ul>
1980's	<ul style="list-style-type: none"> <li>● Lisp Machines developed and marketed.</li> <li>● First expert system shells and commercial applications.</li> </ul>
1980	<ul style="list-style-type: none"> <li>● Lee Erman, Rick Hayes-Roth, Victor Lesser and Raj Reddy published the first description of the blackboard model, as the framework for the HEARSAY-II speech understanding system.</li> <li>● First National Conference of the American Association of Artificial Intelligence (AAAI) held at Stanford.</li> </ul>
1981	<ul style="list-style-type: none"> <li>● Danny Hillis designs the connection machine, a massively parallel architecture that brings new power to AI, and to computation in general. (Later founds Thinking Machines, Inc.)</li> </ul>
1983	<ul style="list-style-type: none"> <li>● John Laird &amp; Paul Rosenbloom, working with Allen Newell, complete CMU dissertations on SOAR.</li> <li>● James Allen invents the Interval Calculus, the first widely used formalization of temporal events.</li> </ul>
Mid 80's	<ul style="list-style-type: none"> <li>● Neural Networks become widely used with the Backpropagation algorithm (first described by Werbos in 1974).</li> </ul>
1985	<ul style="list-style-type: none"> <li>● The autonomous drawing program, Aaron, created by Harold Cohen, is demonstrated at the AAAI National Conference (based on more than a decade of work, and with subsequent work showing major developments).</li> </ul>
1987	<ul style="list-style-type: none"> <li>● Marvin Minsky publishes <i>The Society of Mind</i>, a theoretical description of the mind as a collection of cooperating agents.</li> </ul>
1989	<ul style="list-style-type: none"> <li>● Dean Pomerleau at CMU creates ALVINN (An Autonomous Land Vehicle in a Neural Network), which grew into the system that drove a car coast-to-coast under computer control for all but about 50 of the 2850 miles.</li> </ul>
1990's	<ul style="list-style-type: none"> <li>● Major advances in all areas of AI, with significant demonstrations in machine learning, intelligent tutoring, case-based reasoning, multi-agent planning, scheduling, uncertain reasoning, data mining, natural language understanding and translation, vision, virtual reality, games, and other topics.</li> </ul>

	<ul style="list-style-type: none"> <li>● Rod Brooks' COG Project at MIT, with numerous collaborators, makes significant progress in building a humanoid robot</li> <li>● TD-Gammon, a backgammon program written by Gerry Tesauro, demonstrates that reinforcement learning is powerful enough to create a championship-level game-playing program by competing favorably with world-class players.</li> <li>● EQP theorem prover at Argonne National Labs proves the Robbins Conjecture in mathematics (October-November, 1996).</li> <li>● The Deep Blue chess program beats the current world chess champion, Garry Kasparov, in a widely followed match and rematch). (May 11th, 1997).</li> <li>● NASA's pathfinder mission made a successful landing and the first autonomous robotics system, Sojourner, was deployed on the surface of Mars. (July 4, 1997)</li> <li>● First official Robo-Cup soccer match (1997) featuring table-top matches with 40 teams of interacting robots and over 5000 spectators.</li> <li>● Web crawlers and other AI-based information extraction programs become essential in widespread use of the world-wide-web.</li> <li>● Demonstration of an Intelligent Room and Emotional Agents at MIT's AI Lab. Initiation of work on the Oxygen Architecture, which connects mobile and stationary computers in an adaptive network.</li> </ul>
2000's	<ul style="list-style-type: none"> <li>● Interactive robot pets (a.k.a. "smart toys") become commercially available, realizing the vision of the 18th cen. novelty toy makers.</li> <li>● Cynthia Breazeal at MIT publishes her dissertation on Sociable Machines, describing KISMET, a robot with a face that expresses emotions.</li> <li>● Stanford's autonomous vehicle, Stanley, wins DARPA Grand Challenge race. (October 2005).</li> <li>● The Nomad robot explores remote regions of Antarctica looking for meteorite samples</li> </ul>

## 1.5 The State of Art AI Today

- ▶▶ Artificial intelligence has dramatically changed the business landscape.
- ▶▶ What started as a rule-based automation is now capable of mimicking human interaction.
- ▶▶ It is not just the human-like capabilities that make artificial intelligence unique.
- ▶▶ An advanced AI algorithm offers far better speed and reliability at a much lower cost as compared to its human counterparts.
- ▶▶ Artificial intelligence today is not just a theory. It, in fact, has many practical applications.
- ▶▶ A Gartner research shows that by 2020, at least 30% of companies globally will use AI in at least one fragment of their sales processes.
- ▶▶ Today business across the globe are leveraging artificial intelligence to optimize their process and reap higher revenues and profits.
- ▶▶ Artificial intelligence continues to be a hot topic in the technology space as well as increasing its inception into other realms such as healthcare, business, and gaming.

- ▶▶ Artificial intelligence can play a key role in the sectors like healthcare, agriculture, personal care, home automation, banking and transportation.
- ▶▶ Currently, AI in its very basic form is influencing human life in the form of automated cars, virtual assistants, image recognition software, computer driven online conversations and so on.
- ▶▶ All these are instances of AI's role in the betterment of human life.
- ▶▶ We can also see a lot of global interest among the technological advancements like Cognitive computing, Machine learning and Natural Language Processing.
- ▶▶ These are all small journeys to make machines smarter and self-adaptable compared to the old spoon fed, preprogrammed computing devices

#### **1. Chatbots:**

- (a) AI-powered chatbots in enterprises will also see an influx of people get more comfortable with how AI can actually benefit businesses versus, say, take away their jobs.
- (b) Chatbots, in particular, are always on, delivering smart and flexible analytics through conversations on mobile devices using standard messaging tools and voice-activated interfaces.

#### **2. Artificial Intelligence in eCommerce:**

- (a) Artificial Intelligence technology provides a competitive edge to e-commerce businesses and is becoming readily available to companies of any size or budget.
- (b) Leveraging machine learning, AI software automatically tags, organizes and visually searches content by labeling features of the image or video.
- (c) AI is enabling shoppers to discover associated products whether it is size, color, shape, or even brand.

#### **3. Human Resource Management:**

- (a) AI and Machine learning are going to drastically and irrevocably change how HR and recruitment work in every company and this is going to be awesome.
- (b) In fact, HR is likely to be one of the first areas of business that will benefit from AI for two simple reasons.
- (c) Firstly there are tons of top quality data in HR, and secondly, HR is one part of any company that is both essential and yet feels the pressure of time.
- (d) If aspects of the recruiting and HR job can be automated, the HR workers can have the freedom to directly work with people in the business or potential hires, spending the quality human time necessary for a great HR department.

#### **4. AI in Health Care:**

- (a) In the year ahead, and particularly in the next five to ten years, artificial intelligence is going to have a big impact on the healthcare industry and the ways in which healthcare related companies utilize AI.
- (b) Here is a short note from Dr. Jeff Dunn, CEO of Redivus Health.
- (c) Redivus Health is a transformative mobile app used by healthcare providers to prevent medical errors by offering both clinical decision support during critical medical events as well as documenting those events electronically in real time.

**5. Intelligent Cybersecurity:**

- (a) In regard to cybersecurity, Artificial Intelligence is making great strides.
- (b) Although AI is considered to be in its infancy in cybersecurity and cannot always effectively address all issues, it works successfully in data protection.
- (c) AI allows companies to detect vulnerabilities or anomalous user behavior in such business applications as ERP or Financial system.

**6. The Smartest Investor:**

- (a) In 2009, Ira Sages from Businessweek magazine challenged the Director of Quid AI, Bob Goodson, to program a computer to choose 50 companies that no one had heard of and turn them into the most successful startups.
- (b) Almost 8 years later, the magazine reviewed the list to see how accurate “Goodson and his machine” were.
- (c) The results surprised even the creator: Evernote, Spotify, Etsy, Zynga, Palantir, Cloudera, OPOWER, and the list goes on.
- (d) 20% of the companies the computer chose were valued at a billion dollars.

**7. Better World:**

- (a) AI can help us to prevent future damage and better understand how to address developmental needs while focusing on sustainability.
- (b) A deep understanding of these patterns allows it to make better decisions on the use of the land and implement proper preservation techniques.
- (c) Scientists would be able to use the information obtained to preserve biodiversity and the ecosystem. EarthCube is precisely one of these projects.

**8. A Superhuman Doctor:**

- (a) AI is not only able to save certain areas of the ecosystem, as we already mentioned, but it can also save human lives.
- (b) Through AI and deep learning, doctors can promptly diagnose cancer, before it's too late.<sup>4</sup>
- (c) The Chinese startup Infer vision is using deep learning and image recognition technologies to diagnose possible signs of lung cancer with X-rays.

**9. Sports betting Industry:**

- (a) Taking the human out of sports betting, Gambling Insider argues that, Just as more scientific analysis of sport is changing how coaches, trainers, and clubs play their respective games.
- (b) Greater analysis of sporting events is helping odds making database operators evaluate the potential permutations of each sporting event.
- (c) Increasing the accuracy of that respective odd and thereby making the subsequent odds determination easier.

## 1.6 Some of the Common Application of Artificial Intelligence in Day Today Life

### 1. Siri:

- (a) Everyone is familiar with Apple's personal assistant, Siri.
- (b) She's the friendly voice-activated computer that we interact with on a daily basis.
- (c) She helps us find information, gives us directions, add events to our calendars, helps us send messages and so on.
- (d) Siri is a pseudo-intelligent digital personal assistant. She uses machine-learning technology to get smarter and better able to predict and understand our natural-language questions and requests.

### 2. Alexa:

- (a) Alexa's rise to become the smart home's hub, has been somewhat meteoric.
- (b) When Amazon first introduced Alexa, it took much of the world by storm.
- (c) However, it's usefulness and its uncanny ability to decipher speech from anywhere in the room has made it a revolutionary product that can help us scour the web for information, shop, schedule appointments, set alarms and a million other things, but also help power our smart homes and be a conduit for those that might have limited mobility.

### 3. Tesla:

- (a) This is quite possibly one of the best cars ever made.
- (b) Not only for the fact that it's received so many accolades, but because of its predictive capabilities, self-driving features and sheer technological.
- (c) Anyone that's into technology and cars needs to own a Tesla, and these vehicles are only getting smarter and smarter thanks to their over-the-air updates.

### 4. Cogito:

- (a) Cogito is quite possibly one of the most powerful examples of behavioral adaptation to improve the emotional intelligence of customer support representatives that exists on the market today.
- (b) The company is a fusion of machine learning and behavioral science to improve the customer interaction for phone professionals.
- (c) This applies to millions upon millions of voice calls that are occurring on a daily basis.

### 5. Boxever:

- (a) Boxever, co-founded by CEO, Dave O'Flanagan, is a company that leans heavily on machine learning to improve the customer's experience in the travel industry and deliver 'micro-moments,' or experiences that delight the customers along the way.
- (b) It's through machine learning and the usage of A.I. that the company has dominated the playing field, helping its customers to find new ways to engage their clients in their travel journeys.

**6. John Paul:**

- (a) John Paul, a highly-esteemed luxury travel concierge company helmed by its astute founder, David Amsellem, is another powerful example of potent A.I. in the predictive algorithms for existing-client interactions, able to understand and know their desires and needs on an acute level.
- (b) The company powers the concierge services for millions of customers through the world's largest companies such as VISA, Orange and Air France, and was recently acquired by Accor Hotels.

**7. Amazon.com:**

- (a) Amazon's transactional A.I. is something that's been in existence for quite some time, allowing it to make astronomical amounts of money online.
- (b) With its algorithms refined more and more with each passing year, the company has gotten acutely smart at predicting just what we're interested in purchasing based on our online behavior.
- (c) While Amazon plans to ship products to us before we even know we need them, it hasn't quite gotten there yet. But it's most certainly on its horizons.

**8. Netflix:**

- (a) Netflix provides highly accurate predictive technology based on customer's reactions to films.
- (b) It analyzes billions of records to suggest films that you might like based on your previous reactions and choices of films.
- (c) This tech is getting smarter and smarter by the year as the dataset grows.
- (d) However, the tech's only drawback is that most small-labeled movies go unnoticed while big-named movies grow and balloon on the platform.

**9. Pandora:**

- (a) Pandora's A.I. is quite possibly one of the most revolutionary techs that exists out there today.
- (b) They call it their musical DNA.
- (c) Based on 400 musical characteristics, each song is first manually analyzed by a team of professional musicians based on this criteria, and the system has an incredible track record for recommending songs that would otherwise go unnoticed but that people inherently love.

**10. Nest:**

- (a) Most everyone is familiar with Nest, the learning thermostat that was acquired by Google in January of 2014 for \$3.2 billion.
- (b) The Nest learning thermostat, which, by the way, can now be voice-controlled by Alexa, uses behavioral algorithms to predictively learn from your heating and cooling needs, thus anticipating and adjusting the temperature in your home or office based on your own personal needs, and also now includes a suite of other products such as the Nest cameras.

## 1.7 Future of Artificial Intelligence

- ▶▶ Even though, today the role of AI is confined to specific narrow tasks and they don't have adaptable intelligence that humans exhibit, the influence of AI is drastically growing.
- ▶▶ Research and Markets, a leading Market Research organization's Artificial Intelligence Market - Global Forecast to 2020 report states that the artificial intelligence market is estimated to grow from USD 419.7 Million in 2014 to USD 5.05 Billion by 2020, at a CAGR of 53.65% from 2015 to 2020.
- ▶▶ AI holds the power to redefine the current work environment in IT enterprises especially the way Knowledge capital and people capital are deployed.
- ▶▶ As labor force adapts to the demands of a new technology revolution, it leads to economic prosperity as well.
- ▶▶ It brings in tremendous opportunities in enterprises to deploy knowledge and people towards value creation as opposed to process management.
- ▶▶ To tap this huge potential, technology companies in India and abroad have started offering Artificial Intelligence platform as a solution or as a service (AIaaS).
- ▶▶ With AI getting more mature, let us expect humans will get more empowered with self-learning machines that can create a smarter competition with the human brains and that will probably redefine the whole business ecosystem.

## 1.8 Chapter Based Questions

1. What is Artificial Intelligence? Define and explain.
2. Explain what is Intelligence?
3. Explain some Foundations on which Artificial intelligence is based.
4. Explain brief history of AI.
5. Explain the state of art in AI today's Era.
6. Give some real life application of Artificial Intelligence.
7. Write a note on Future of Artificial Intelligence.
8. Write a note on Turing test.
9. What is a cognitive approach in AI ?
10. Mention the applications of AI in today's world.

