# **Artificial Intelligence Question Compilation**

(Courtesy of [Sean McGroarty](https://github.com/McGizzle))

Questions: https://github.com/nating/cs-exams/blob/master/assets/question-compilations/third-year/artificial-intelligence.md

Solutions: https://github.com/nating/cs-exams/blob/master/assets/solutions/artificial-intelligence/artificial-intelligence.md

## **Q1 (theory parts)**

(✝) = an agent acting intelligently in its environment

### **1a)**

What is the Symbol System Hypothesis & what does it have to do with (✝)?

* The hypothesis states that all reasoning can be expressed as symbol manipulation, given a physical symbol system that combine symbols into structures/expressions, and manipulates them to create new expressions. This relates to (✝), as an intelligent agent can manipulate symbols. The environment it acts in is the symbol system, and its acts are symbol manipulations. Therefore based on the hypothesis it is proposed that an intelligent agent can reason.

### **1b)**

What does search have to do with non-determinism?

* A non-deterministic algorithm, given the same input, may behaviour differently on different runs. When an intelligent agent searches a graph node by node, the next node in the graph is non-deterministic. There is no way of telling what the next node traversed will be as the agent must make intelligent choices, and as a result may behave non-deterministically.

### **1c)**

State precisely the sense in which Cantors theorem says that the set of infinite bit strings cannot be searched.

* Cantor’s theorem states that for any set A, the power set of A has strictly greater cardinality than A (itself). The power of set of an countably infinite set (e.g. a set with cardinality the same as the natural numbers), is uncountably infinite (i.e has the same cardinality as the real numbers.)
* This means that to search a set of infinite bit strings, would mean to search the power set of that infinite bit string, which, by Cantor’s theorem, is uncountably infinite.

### **1d)**

What is the problem SAT of Boolean satisfiability, and what does it have to do with finite bit strings?

* SAT is the problem of seeing whether a boolean expression is satisfiable. A boolean expression, with a finite amount of boolean variables a,b,c,d,e,f.... is like a finite bit string, where each variable can take one of two values. The SAT problem is finding out if there is a combination of values these variables can take (like a combination of 1s and 0s) so that the expression will be satisfied. An intelligent agent acts to find this expression.

### **1e)**

How is exponentiation relevant to SAT and polynomial time computability?

* With *n* boolean variables there are different possible bit strings of length n, i.e. the search space is exponential. To search this space using a brute force solution takes worse than polynomial time.

### **1f)**

What is a binary decision diagram (BDD), and what does it mean to be ordered and reduced?

* A BDD is a rooted, acyclic graph with terminal nodes of the values 0/1. Branching depends on the boolean variable value of the node.
* Ordered: A nodes variable index must be less than that of any of its children.
* Reduced: High and Low children of a node cannot be the same. They must be opposite in order to arrive at a terminal node.

### **1g)**

Give an ordered and reduced tree for the following Boolean expression:

( x ∨ y ) ∧ ( x' ∨ y' )

### **1h)**

What is a Turing Machine and what does it have to do with (✝)?

* A Turing machine is a hypothetical machine that can determine a result from a set of input variables. A Turing machine can be seen as an agent acting intelligently in its environment, thinking of the set of input variables as its environment and its action as the result.

### **1i)**

What is the Halting Problem and how is it relevant to (✝)?

* The Halting Problem states: HP(P,D) := (1 if P halts on D, 0 otherwise)
* There exists no program (HP) that given another program (P) and data (D) as input that will output 1 if the program halts or 0 otherwise.
* An Intelligent Agent which is given a goal, may take forever to determine whether that goal can be satisfied.

### **1j)**

What is SAT and how is it relevant to (✝)?

* SAT is the problem of seeing whether a boolean expression is satisfiable.
* The agent might be tasked with the computation. Boolean expressions are ways of expressing the computation of the agent.

### **1k)**

What is P vs NP and how is SAT relevant to it?

* P are all the problems a deterministic Turing machine can solve in polynomial time.
* NP are are the problems a non-deterministic Turing machine can solve in polynomial time.
* Checking whether an assignment satisfies a boolean expression is a P problem.
* Finding the assignments which satisfy the boolean expression is a NP problem.

### **1l)**

What is the Church-Turing thesis and what does it add to Symbol-System hypothesis in addressing (✝)?

* The thesis states that any symbol manipulation can be carried out by a Turing machine. This means that a Turing machine can be seen as an intelligent agent, since it can manipulate symbols, and therefore reason.

### **1m)**

What are the ingredients of a CSP?

1. Variables
2. Domain
3. Constraints

### **1n)**

What is the generate and test approach in CSP?

* This is a brute force approach in which every possible solution is generated. Then these solutions are all tested to see if they satisfy the criteria.

### **1o)**

What does it mean for A\* to be admissible, and what three things are necessary for A\* to be admissible?

* If there in a solution, A\* will find the optimal solution.

1. Branching factor must be finite
2. Arc costs must be bounded above 0
3. The heuristic must be an underestimate

### **1p)**

When is an ordered BDD satisfiable?

* Precisely when it is not equal to 0.

### **1q)**

What do non-determinism and search have to do with (✝)?

* Intelligent action comes with the need to make a choice based on a heuristic.
* When searching, the intelligent agent will need to be non-deterministic in its approach and make choices based on the heuristic.

### **1r)**

What is non-determinism?

* A nondeterministic algorithm is an algorithm that, even for the same input, can exhibit different behaviors on different runs.

## **2017**

### **1s)**

What is Marr’s tri-level hypothesis and what does it have to do with AI?

Marr treated vision as an information processing system. He put forth the idea that one must understand information processing systems at three distinct, complementary levels of analysis. This idea is known in cognitive science as Marr’s Tri-Level Hypothesis:

· **Computational Level:** What does the system do, what problems does it solve and why does it do these things.

· **Algorithmic Level:** How does the system do what it does, specifically, what representations does it use and what processes does it employ to build and manipulate the representations.

· **Implementation/Physical Level:** How is the system physically realised (e.g computer, neural structures, mechanical implementation etc…)

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### **1t)**

What is a Constraint Satisfaction Problem (CSP)? Is the Halting Problem a CSP? Is SAT a CSP? Explain, formulating either or both as a CSP in case either or both are.

A **Constraint Satisfaction Problem (CSP)** is a mathematical question defined as a set of objects who must satisfy a number of constraints or limitations. CSP’s represent the entities in a problem as a collection of finite constraints over variables, which is solved by constraint satisfaction methods. CSP’s are very popular in the field of artificial intelligence since the regularity in their formulation provides a common basis to analyse and solve problems of many seemingly unrelated families. CSP’s often exhibit high complexity, requiring a combination of heuristics and combinational search methods to be solved in a reasonable time.

The **Boolean Satisfiability Problem (SAT)** can be roughly thought of as a CSP. Consider the example problem:

Halting Problem is not CSP, program and input domain are infinite

SAT is: Var = variables of boolean expression, Dom = [true, flase], Con=??