AQA Computer Science A-Level

4.4.5 A model of computation

Concise Notes

<u>Specification:</u>

4.4.5.1 Turing machine:

Be familiar with the structure and use of Turing machines that perform simple computations.

Know that a Turing machine can be viewed as a computer with a single fixed program, expressed using:

- A finite set of states in a state transition diagram
- A finite alphabet of symbols
- An infinite tape with marked-off squares
- A sensing read-write head that can travel along the tape, one square at a time.

One of the states is called a start state and states that have no outgoing transitions are called halting states.

Understand the equivalence between a transition function and a state transition diagram.

Be able to:

- Represent transition rules using a transition function
- Represent transition rules using a state transition diagram
- Hand-trace simple Turing machines

Be able to explain the importance of Turing machines and the Universal Turing machine to the subject of computation.

Turing Machines

- Formal models of computation
- Consist of:
    - a finite state machine
    - a read/write head
    - a tape that is infinitely long in one direction and divided into cells
- Each tape cell can be left blank or contain a symbol
- The set of symbols used is called the alphabet
- A Turing machine's alphabet must be finite
- Run a single program, defined by a finite state machine
- The finite state machine will have a single start state and may have a number of halting states
- Stop after reaching their halting state which:
    - can be entered at any point in the machine's execution
    - is entered once all of the input data has been processed
- More powerful than finite state machines as a model of computation because they can utilise a greater range of languages thanks to their infinitely long tape

Transition Functions

- Can be used to define the rules followed by Turing machines
- Written in the form:

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δ(current state, read) = (new state, write, move)
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- δ is the Greek letter delta
- Have an equivalence with transition rules in a state transition diagram

Universal Turing Machines

- Can represent any finite state machine
- Read a description of a finite state machine from the same tape as the input data
- Can be said to act as interpreters because they read their instructions in sequence before executing operations

The importance of Turing machines

- Turing machines provide a definition of what is computable
- Turing machines can be used to prove that there are problems which cannot be solved by computers