Theoretical Aspects of Computer Science
(380CT)

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The team

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- Dr Abdulrahman Altahhan (ab8556)
- Dr Matthew England (ab9797)
- Dr Rob Low (mtx014)

380CT?

380CT?

1. Foundations of CS: practical & theoretical understanding.

- What is an “algorithm”?
- How “hard” is a problem?
- Can we “compute/solve” anything?
- If not then what are the limits.

380CT?

1. Foundations of CS: practical & theoretical understanding.
2. Formal specification of patterns and “languages.”

For example:

- $a^*b^*, a^nb^n, a^ib^jc^k$
- $\{w \in \{0,1\}^* \mid w \text{ has equal number of 0s and 1s}\}$
- L recognized by a given automaton

380CT?

1. Foundations of CS: practical & theoretical understanding.
2. Formal specification of patterns and “languages.”
3. Models of computation and the issues of computability and complexity.

- Deterministic/Non-Deterministic Automoata (DFA/NFA)
- Push Down Automata (PDA)
- Turing Machines (TM).

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1. Foundations of CS: practical & theoretical understanding.
2. Formal specification of patterns and “languages.”
3. Models of computation and the issues of computability and complexity.
4. Algorithmic techniques used to tackle complex problems.

- Complexity classes: P, NP, NP-complete, NP-hard, etc.
- Algorithms to solve or heuristics to try...

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It’s fun, cool, intellectually challenging, insightful, . . .

. . . it is! :-)


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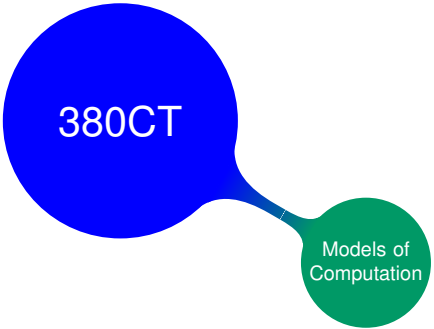
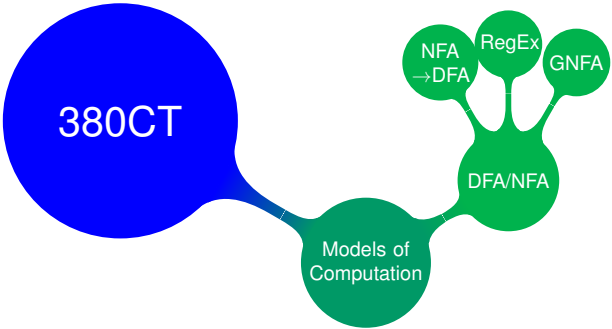

380CT
Models of Computation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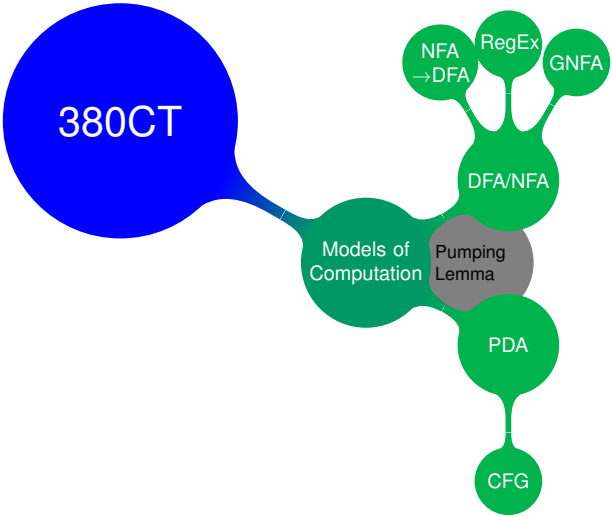
Models of Computation
DFA/NFA
NFA →DFA
RegEx
GNFA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Models of Computation
Pumping Lemma
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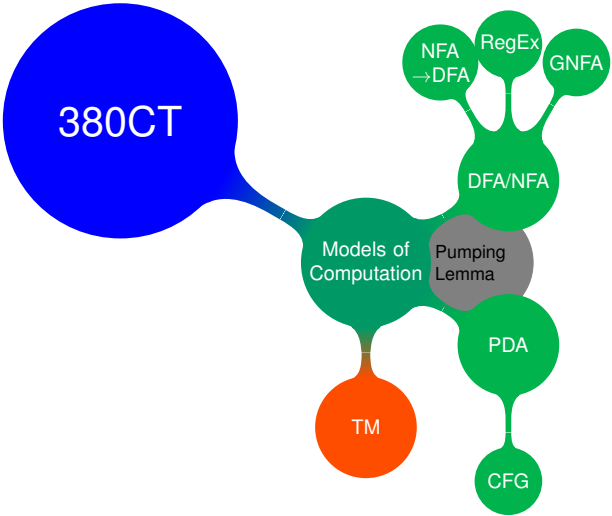
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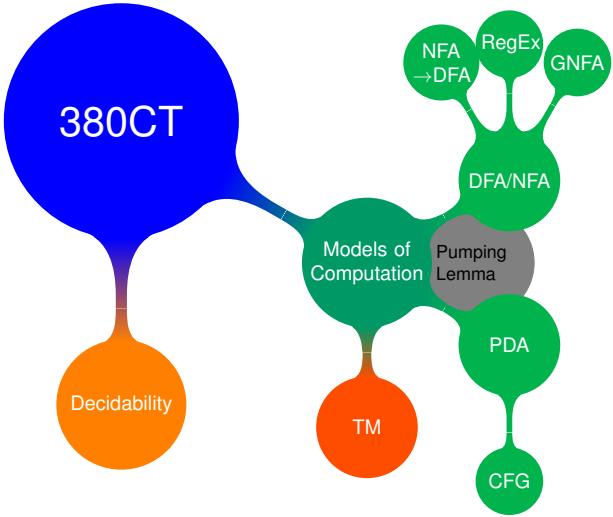
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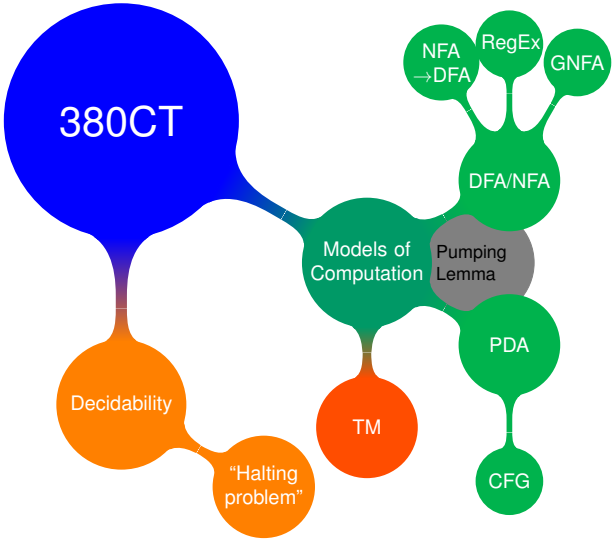
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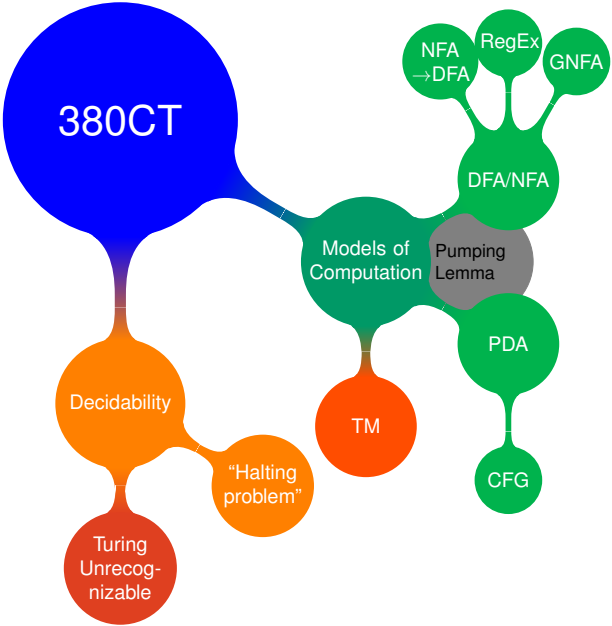
Decidability
“Halting problem”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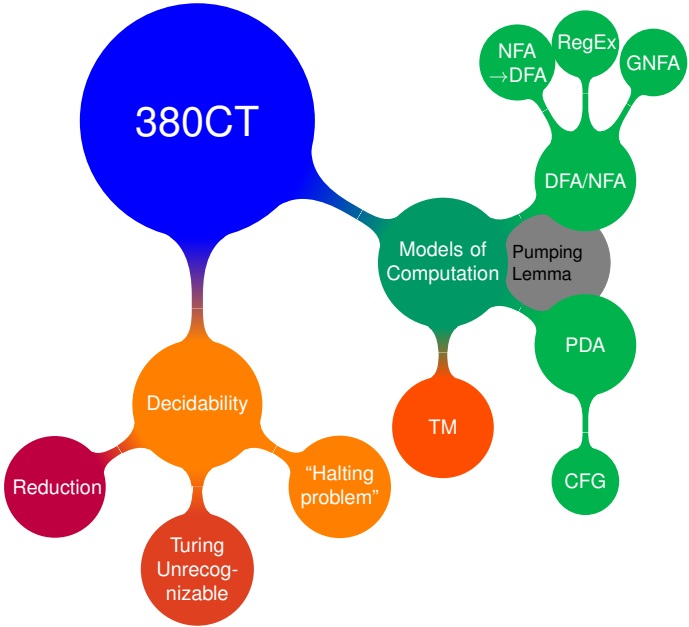
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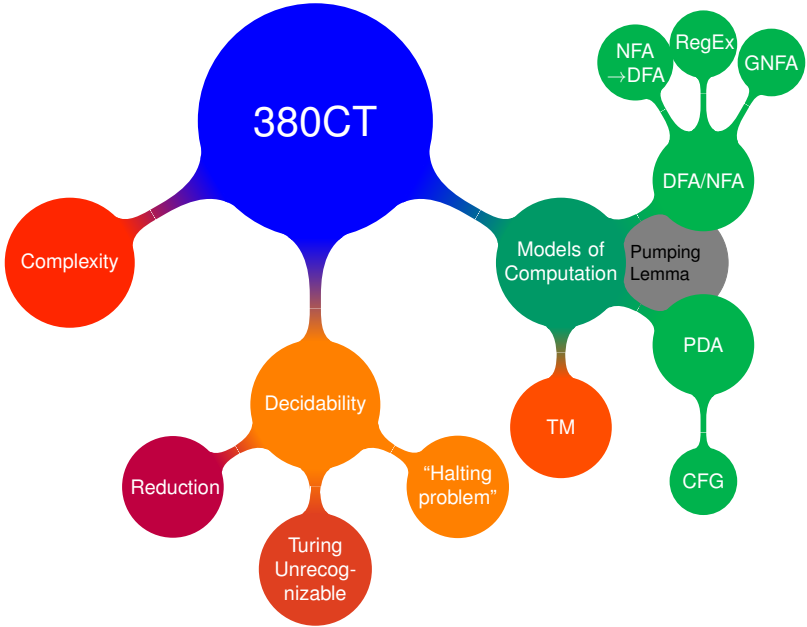
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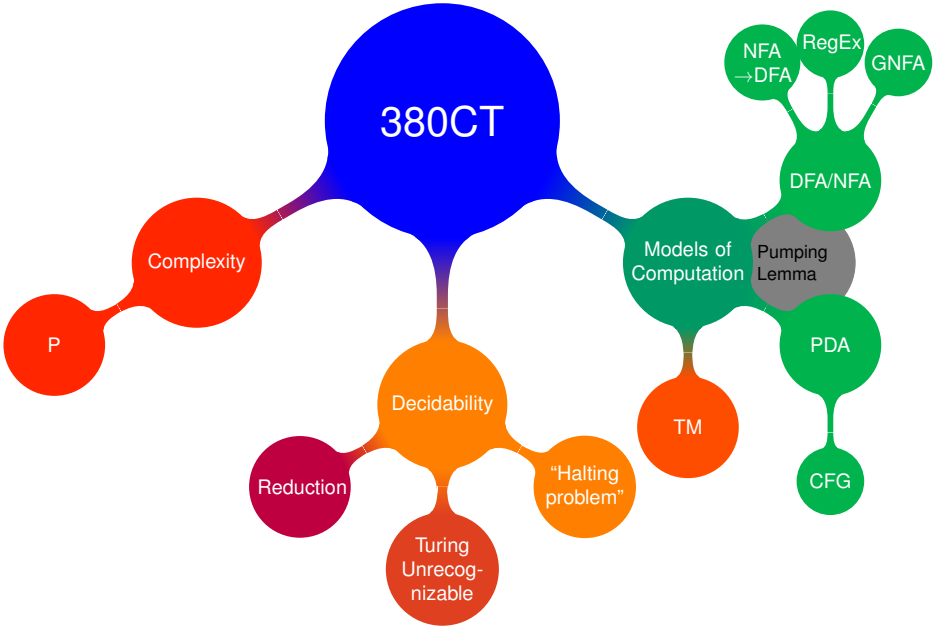
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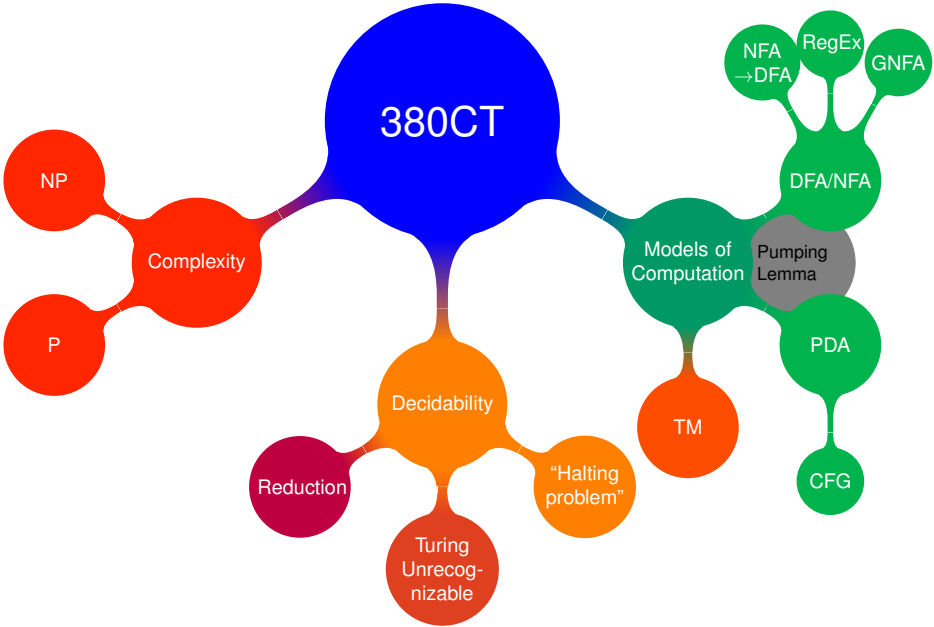
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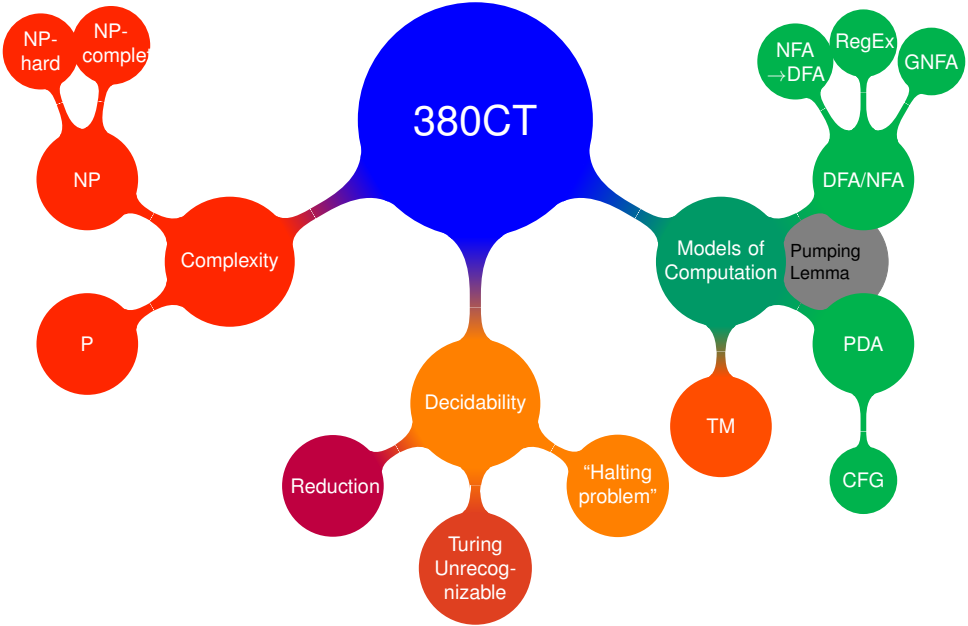
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NP-hard
NP-complete
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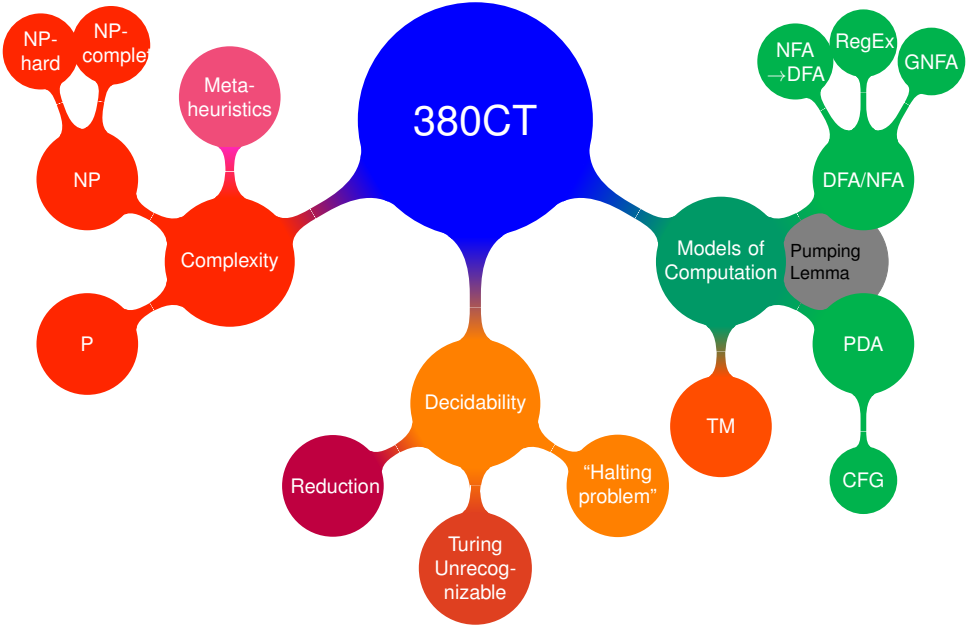
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Intended Module Learning Outcomes

On completion of this module the student should be able to:

1. Use **formal** notation to *specify* **patterns** and **languages**.

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5. *Specify* and *implement* methods to **estimate** solutions to **intractable problems**.

Teaching and Learning

- Lectures: Mon 9am.
- Tutorials/exercises – check your timetable.
- Pen and paper, JFLAP, GeoGebra, Programming.
- Formative tests.

Develop a portfolio of practical exercises.

Laboratory	48 hours	24%
Lecture	24 hours	12%
Self guided	128 hours	64%
Total	200 hours	

Assessment

Assessement: 50% Coursework and 50% Exam.
Resits: second portfolio and exam
Pass requirements:

- Coursework $\geq 35\%$
- **and** Exam $\geq 35\%$
- **and** Module Mark $\geq 40\%$.

Indicative Content

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- **Algorithms and Heuristics** Exhaustive search, Approximation Algorithms, Greedy Algorithms, Metaheuristics. Pseudocode and implementation (C++, Python, . . .).

Books

Essential Reading

Sipser, M. (1997) **Introduction to the Theory of Computation.** 2nd Edn. Thomson Course Technology Inc

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- Dean, N. (1996) **The Essence of Discrete Mathematics.** Prentice Hall
- Hoos, H. and Stutzler, T. (2005) **Stochastic Local Search: Foundations and Applications.** Morgan Kaufmann

Pre-requisites

- **210CT**
  - Algorithms (Searching and sorting, Recursion, Divide and Conquer strategies, Greedy algorithms)
  - Complexity and efficiency (Time and space complexity, Big-O notation)

Pre-requisites

- **124MS**
  - Propositional Calculus (Statements, $\implies$, $\iff$, $\neg, \wedge, \vee, \subset, \supset, \in$, Truth tables. Formal proof.)
  - Predicate calculus (Predicates, $\exists, \forall$)
  - Sets and Functions (Subset, Cardinality, Venn diagrams, Functions, domain and codomain, Composition and inverse. Relations.)
  - Algebra (Congruences)
  - Graph Theory (connectivity, depth and breadth first search, shortest path, Trees)
  - Algorithms (Uncomputable problems. Asymptotic efficiency. Heuristic algorithms)

Polynomials vs Eponentials

Realtime Moodle quiz. . .