The Hong Kong University of Science and Technology (Guangzhou)

UG Course Syllabus

[Course Title] Theories in Computing

[Course Code] DSAA3071

[No. of Credits] 3

[Any pre-/co-requisites] DSAA 1011 Foundations of Data Science and Analytics

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Course Description

This course provides a rigorous introduction to the theory of computation, covering three main areas: automata and formal languages, computability theory, and complexity theory. Students will explore fundamental models of computation including finite automata, pushdown automata, and Turing machines, as well as their theoretical limitations. The course introduces key concepts such as decidability, undecidability, and the Church-Turing thesis, culminating in an exploration of complexity classes including P, NP, and PSPACE, along with the theory of NP-completeness.

The course employs a Test-Driven, AI-Assisted learning format with structured in-class sessions combining testing, AI-assisted learning, and collaborative discussion. The textbook is Sipser's Introduction to the Theory of Computation (3rd edition).

Intended Learning Outcomes (ILOs)

By the end of this course, students should be able to:

1. Understand the equivalence of decision problems, language recognition problems, the limitations of different classes of computational machine (finite automata, pushdown automata, Turing machine) in recognizing different classes of language.

2. Prove the equivalence of DFA, NFA, regular expressions and the equivalence of PDA and CFG.

3. Design finite automata and write regular expressions for regular languages.

4. Write context-free grammar (CFG) for context-free languages, especially for expressions occurring in programming languages.

5. Design pushdown automata for context-free languages and construct a PDA that accepts the language generated by a given context-free grammar.

6. Convert a non-deterministic finite automaton (NFA) to a deterministic finite automaton (DFA).

7. Understand the Church-Turing thesis and the unsolvability of the halting problem, and apply the reduction technique to prove the undecidability of decision problems, particularly in language recognition.

8. Understand the concepts of P, NP, and NP-completeness and use reductions to prove that a given problem is NP-complete.

Weekly Schedule and Weekly ILOs

Week	Topics	Weekly ILOs
1	Finite Automata, NFA, Regular Operations (1.1-1.3)	Define DFAs/NFAs; convert NFA→DFA; build NFAs from regex
2	Regular Expressions, Pumping Lemma (1.3-1.4)	Convert regex↔automata; apply pumping lemma
3	Context-Free Grammars, PDAs (2.1-2.2)	Design CFGs; construct PDAs; CFG-PDA equivalence
4	Non-CFLs, CFL Pumping Lemma (2.3, 3.1)	Apply CFL pumping lemma; define Turing machines
5	TM Variants, Church-Turing Thesis (3.2-3.3)	TM equivalence; Church-Turing thesis
6	Decidability, Undecidability (4.1-4.2)	Decidable vs recognizable; halting problem
7	Reducibility, Rice's Theorem (5.1-5.3)	Mapping reductions; Rice's theorem
8	Time Complexity, Class P (7.1-7.2)	Running time; big-O; problems in P
9	Class NP, NP-completeness (7.3-7.4)	Define NP; NP-completeness proofs
10	More NP-complete Problems (7.5)	Reduction techniques for NP-completeness
11	Space Complexity, PSPACE (8.1-8.3)	Space complexity; Savitch's theorem; PSPACE
12	L, NL, NL-completeness (8.4-8.5)	Log-space classes; NL = coNL
13	Hierarchy Theorems, BPP (9.1-9.2, 10.2)	Hierarchy theorems; oracle TMs; BPP

Assessment and Grading

This course will be assessed using criterion-referencing and grades will not be assigned using a curve. Detailed rubrics for each assignment are provided below, outlining the criteria used for evaluation.

Assessments:

Assessment Task	Contribution to Overall Course grade (%)	Due date
In-class Tests (12 tests, 30 min each)	30%	Weekly
Final Examination (2 hours)	70%	End of semester

* Assessment marks for individual assessed tasks will be released within two weeks of the due date.

Mapping of Course ILOs to Assessment Tasks

Assessed Task	Mapped ILOs	Explanation
In-class Tests	ILO1-ILO8	This task assesses students' ability to understand the knowledge, apply skills, and synthesize solutions for topics learned in the last lecture. As such, they collectively cover all the ILOs.
Final Examination	ILO1-ILO8	This task assesses students' ability to understand the knowledge, apply skills, and synthesize solutions for all the topics learned in the course. As such, they collectively cover all the ILOs.

Grading Rubrics

Grading rubrics are based on following criteria:

1. Conceptual Understanding: Accuracy and depth of explanations; appropriate use of domain-specific concepts and terminology.
2. Technical and Analytical Quality: Quality of analyzing the problem, solve the problem and analyze the solution.
3. Reasoning, Justification and Innovation: Ability to compare alternatives, articulate tradeoffs, and justify design decisions in writing and/or presentations. Demonstration of the ability to connect knowledge in different sub-field, take a novel perspective in solving problems, or ask insightful questions.
4. Communication: Organization, clarity, and coherence of written work or oral presentations
5. Teamwork: Evidence of participation in the discussion and shared contribution, coordination, and professional collaboration

To encourage learning, the maximum mark of the in-class tests are 130 points, yet capped at 100 points.

Final Grade Descriptors:

Grades	Short Description	Elaboration on subject grading description
A	Excellent Performance	Demonstrates a comprehensive grasp of subject matter, expertise in problem-solving, and significant creativity in thinking. Exhibits a high capacity for scholarship and collaboration, going beyond core requirements to achieve learning goals.
B	Good Performance	Shows good knowledge and understanding of the main subject matter, competence in problem-solving, and the ability to analyze and evaluate issues. Displays high motivation to learn and the ability to work effectively with others.
C	Satisfactory Performance	Possesses adequate knowledge of core subject matter, competence in dealing with familiar problems, and some

		capacity for analysis and critical thinking. Shows persistence and effort to achieve broadly defined learning goals.
D	Marginal Pass	Has threshold knowledge of core subject matter, potential to achieve key professional skills, and the ability to make basic judgments. Benefits from the course and has the potential to develop in the discipline.
F	Fail	Demonstrates insufficient understanding of the subject matter and lacks the necessary problem-solving skills. Shows limited ability to think critically or analytically and exhibits minimal effort towards achieving learning goals. Does not meet the threshold requirements for professional practice or development in the discipline.

Final Grade Rules:

- A (A+ A A-): Overall Course Grade >= 85 AND Ranked in the top 30%
    - A+: Overall Course Grade >=95 AND Ranked in the top 10%)
- B (B+ B B-): Overall Course Grade >=70
- C (C+ C C-): Overall Course Grade >= 60
- D: Overall Course Grade >= 50
- F: Overall Course Grade < 50

All subgrades except A+ (e.g. A-, B+, etc.) will be assigned based on the outcome of the overall course grades.

Course AI Policy

This course uses **Test-Driven, AI-Assisted (AI-assisted)** learning:
• **Session 1**: Closed-book test + introduction (no AI)
• **Session 2**: AI-assisted learning in groups of 4 (AI encouraged)
• **Session 3**: Panel discussion + validation (limited AI)
Tests and final exam are closed-book with no AI access.

Communication and Feedback

Assessment marks for individual assessed tasks will be communicated via Canvas within two weeks of submission. Students who have further questions about the feedback including marks should consult the GTA and then the instructor within five working days after the feedback is received.

Resubmission Policy

Not applicable. All assessments are in-class tests and final exam.

Required Texts and Materials

• Sipser, Michael. Introduction to the Theory of Computation, 3rd Ed. (Chapters 1-5, 7-8, 9.1-9.2, 10.2)
• MIT OCW 18.404J video lectures (supplementary)

• Course website: https://giggleliu.github.io/DSAA3071TheoryOfComputation/
• Laptop **required** for AI-assisted sessions

Academic Integrity

Students are expected to adhere to the university's academic integrity policy. Students are expected to uphold HKUST(GZ)'s Academic Honor Code and to maintain the highest standards of academic integrity. The University has zero tolerance of academic misconduct. Please refer to Regulations for Academic Integrity and Student Conduct for the University's definition of plagiarism and ways to avoid cheating and plagiarism.

[Optional] Additional Resources

• Course website: https://giggleliu.github.io/DSAA3071TheoryOfComputation/
• MIT 18.404J YouTube:
https://www.youtube.com/playlist?list=PLUl4u3cNGP60_JNv2MmK3wkOt9syvfQWY
• Zulip: zulip.hkust-gz.edu.cn, stream: DSAA3071-2026-Spring